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BY MARY SOMERVILLE,

AUTHOR OF THE 'CONNEXION OF THE PHYSICAL SCIENCES,'
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SIXTH EDITION, THOROUGHLY REVISED

BY H. W. BATES,

ASSISTANT SECRETARY TO THE ROYAL GEOGRAPHICAL SOCIETY; AUTHOR
OF THE 'NATURALIST ON THE RIVER AMAZONS.'

WITH PORTRAIT OF THE AUTHOR.

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TO

SIR JOHN F. W. HERSCHEL, BART., K.H.,

&c. &c. &c.

DEAR SIR JOHN,

I HAVE much pleasure in again availing myself of your permission to inscribe this book to you, as it gives me an opportunity of assuring you once more of my admiration of your talents, my high appreciation of the services you have conferred upon science, and of my sincere estimation of your friendship.

I remain, with great regard,

Yours truly,

MARY SOMERVILLE.

La Spezzia, 1862.

PREFACE TO SIXTH EDITION.

It has been the author's desire in this as in the previous editions of the present work, to adapt it to the existing state of our knowledge of geography and the allied sciences, which have made such rapid progress during the last few years. The task of embodying all the important new information, and of correcting the previous descriptions by the light of recent research, has been entrusted to Mr. H. W. Bates, whose opportunities as Assistant Secretary of the Royal Geographical Society, and qualifications as a scientific explorer, gave the author full confidence that the work would be well executed. Without altering, in any essential point, the plan of the work or the general views entertained by the author, he has largely modified the statements of facts and minor conclusions, in accordance with the results of recent scientific investigation.[1]

---

[1] The sources from which the additions to the work have been derived are too numerous to be here mentioned. Suffice it to say that the Transactions of the Royal Geographical and other similar Societies, the Reports of official surveys of various countries and in various languages, and all the best recent books of Travel, have been consulted, and all numerical statements carefully compared and tested.

The chapters relating to Meteorology and allied subjects have further been revised by Mr. Alexander Buchan, Secretary to the Scottish Meteorological Society, to whom and to Miss Chessar, Geographical Lecturer at the Home and Colonial Training College, who aided in the arduous research into original authorities, the work is also greatly indebted for its present completeness.

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§ 1. PHYSICAL Geography is a description of the earth, the sea, and the air, with their inhabitants animal and vegetable, so far as regards the distribution of these organised beings, and the causes of that distribution. Political and arbitrary divisions are disregarded, the sea and the land are considered only with respect to those great features that have been stamped upon them by the hand of the Almighty, and man himself is viewed but as a fellow-inhabitant of the globe with other created things, yet influencing them to a certain extent by his actions, and influenced in return. The effects of his intellectual superiority on the inferior animals, and even on his own condition, by the subjection of some of the most powerful agents in nature to his will, together with the other causes which have had the greatest influence on his physical and moral state, are among the most important subjects of this science.

The former state of our terrestrial habitation, the successive convulsions which have ultimately led to its present geographical arrangement, and to the actual distribution of land and water, so powerfully influential on the destinies of mankind, are circumstances of primary importance.

§ 2. The position of the earth with regard to the sun, and its connexion with the bodies of the solar system, have been noticed in another work of the author's.[1] It has been there shown that our globe forms but an atom in the immensity of space, utterly invisible from the nearest fixed star and scarcely a telescopic object to the remoter planets of our system. The increase of temperature with the depth below the surface of the earth, and the tremendous desolation hurled over wide regions by numerous fire-breathing mountains, show that man is removed but a few miles from immense lakes or seas of liquid fire. The very shell on which he stands is unstable under his feet, not only from those temporary convulsions that seem to shake the globe to its centre, but from a slow almost imperceptible elevation in some places, and an equally gentle subsidence in others, as if the internal molten matter were subject to secular tides, now heaving and now ebbing, or that the subjacent rocks were in one place expanded and in another contracted by changes of temperature.

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[1] Somerville's 'Connexion of the Physical Sciences.'

The earthquake and the torrent, the august and terrible ministers of Almighty Power, have torn the solid earth and opened the seals of the most ancient records of creation, written in indelible characters on the "perpetual hills and the everlasting mountains." There we read of the changes that have brought the rude mass to its present fair state, and of the myriads of organic species that have appeared on this mortal stage, have fulfilled their destinies, and have successively disappeared to make way for new races, which, in their turn, have vanished from the scene, till the creation of man completed the glorious work. Who shall define the periods of those mornings and evenings when God saw that his work was good? and who shall declare the time allotted for the human race, when the generations of the most insignificant insect existed for unnumbered ages? Yet man is also to vanish in the ever-changing course of events. These stupendous changes may be but cycles in those great laws of the universe where all is variable but the laws themselves, and He who has ordained them.

§ 3. The earth is one of 105 planets which revolve about the sun in elliptical orbits: of these 98 have been discovered since the year 1781. Mercury and Venus are nearer the sun than the earth, the others are more remote. 97 are of small dimensions and revolve between the orbits of Mars and Jupiter. The earth revolves at a mean distance of 91,430,000 miles from the sun's centre, in a civil year of 365 days 6 hours 9 minutes, at the same time that it rotates in 24 hours about an axis which always remains parallel to itself, and inclined at an angle of $23^{\circ}\ 27'\ 28''{\cdot}75$ to the plane of the ecliptic; consequently the days and nights are of equal length at the equator, from whence they progressively differ more and more as the latitude increases, till at each pole alternately there is perpetual day for six months, and a night of the same duration: thus the light and heat are very unequally distributed, and both are modified by the atmosphere by which the earth is surrounded, and which extends to the height of more than 100 miles.

With regard to magnitude, Mars, Jupiter, Saturn, Uranus, and Neptune, are larger than the earth, the rest are smaller; but even the largest is incomparably inferior to the sun in size: his mass is 354,936 times greater than that of the earth, but the earth is nearly four times as dense.

§ 4. Though the planets disturb the earth in its motion, their form has no effect on account of their great distance; but it is otherwise with regard to the moon, which revolves about the earth at a mean distance of 238,793 miles, and is therefore so near that the form of both bodies causes mutual disturbances in their respective motions. The perturbations in the moon's motions from that cause, compared with the same computed from theory, show that the earth is not a perfect sphere, but that it bulges at the equator, and is flattened at the poles: they even give a value of this compression[1] or flattening. Again, theory shows that, if the earth were throughout of the same density, it would be much less compressed at the poles than the moon's motions show it to be, but that it would be very nearly the same were the earth to increase regularly in density from the surface to its centre; and thus the lunar motions not only make known the form, but reveal the internal structure of our globe. Actual measurement has proved the truth of these results.

The courses of the great rivers, which are generally navigable to a considerable extent, show that the curvature of the land differs but little from that of the ocean; and as the heights of the mountains and continents are inconsiderable when compared with the magnitude of the earth, its figure is understood to be determined by a surface at every point perpendicular to the direction of gravitation, or of the plumb-line, and is the same which the sea would have if it were continued all round the earth beneath the continents. Such is the figure that has been measured in various parts of the globe.

§ 5. A terrestrial meridian is a line passing through both poles, all the points on which have their noon contemporaneously, and a degree of a meridian is its 180th part. The lines perpendicular to it are the parallels of latitude. Now, if the earth were a perfect sphere, all degrees of latitude would be of the same length; but, as it is flattened at the poles, the degrees are longest there, and decrease in length to the equator. The form and size of the earth may therefore be determined by comparing the length of degrees of the meridian in different latitudes.[2] Eleven arcs have been measured in Europe, one in the Andes of equatorial America, two in British India, and one at the Cape of Good Hope; but a comparison of no two gives identical results, which shows that the earth has a slightly irregular form. From a mean of 10 of these arcs M. Bessel has deduced that the equatorial radius of the earth is 3963·025 miles, and the polar radius 3949·8 miles. Whence, assuming the earth to be a sphere, the length of a mean degree of the meridian is 69·05 British statute miles; therefôre 360 degrees, or the whole circumference of the globe, is 24,858 miles; the diameter, which is something less than a third of the circumference, is about 8286 statute miles; and the length of a geographical mile of 60 to a degree is 6086·76 feet. The breadth of the torrid zone is 2815 geographical miles, the breadth of each of the temperate zones is 2854 miles, and that of each of the spaces within the arctic and antartic circles 1140 miles nearly. The results obtained by Mr. Airy, the Astronomer Royal, 10 years afterwards, only differ from those of M. Bessel by 117 feet in the equatorial, and 148 feet in the polar radius, quantities not greater than the length of a good-sized ball-room. In consequence of the round form of the earth, the dip or depression of the horizon is in round numbers a fathom for every three miles of distance; that is to say, an object a fathom or six feet high would be hid by the curvature of the earth at the distance of three miles. Since the dip increases as the square, a hill 100 fathoms high would be hid at the distance of 10 miles; and the top of Mount Everest, the most elevated point of the Himalaya hitherto measured, 29,002 feet high, would be seen to sink beneath the horizon by a person about 169 miles off: thus, when the height is known, an estimate can be formed of the distance of a mountain by observing its angular distance above the sea-horizon.

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[1] The compression of the earth is the flattening at the poles. Its numerical value is equal to the difference between the equatorial and polar diameters, expressed in feet or miles, divided by the equatorial diameter.

[2] The theoretical investigation of the figure of the earth, the method employed for measuring arcs of the meridian, and that of deducing the form

§ 6. The oscillations of the pendulum have afforded another method of ascertaining the form of the earth. Like all heavy bodies, its descent and consequently its oscillations are accelerated in proportion to the force of gravitation, which increases from the equator to the poles. In order, therefore, that the oscillations may be everywhere performed in the same time, the length of the pendulum must be increased progressively in going from the equator to the poles, according to a known law,[1] from whence the compression or flattening

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of the earth from the oscillations of the pendulum, are given in the 6th section of the 'Connexion of the Physical Sciences,' by Mary Somerville, 8th edition.

[1] A pendulum which oscillates 86,400 times in a mean day at the equator, will do the same at every point of the earth's surface if its length be increased progressively to the pole as the square of the sine of the latitude. The sine of the latitude is a perpendicular line drawn from any point of a terrestrial meridian to the equatorial radius of the earth. That line ex-

at the poles may be deduced. Experiments for that purpose have been made in a great number of places; but, as in the measurement of the meridian arcs, no two sets give exactly the same results. The mean of the whole, however, differs very little from that given by the measurement of degrees of the meridian and the perturbations of the moon; and as the three methods are so entirely independent of each other, the figure and dimensions of the earth may be considered to be known with great accuracy. The sea has little effect on these experiments, both because its density is less than that of the earth, and that its mean depth of perhaps four miles is inconsiderable when compared with 3956 miles, the mean terrestrial radius.[1]

The discrepancies in the results from the comparison of the different sets of pendulum experiments, and also of measured degrees of the meridian, can only arise from local attraction, and from irregularities in the form of the earth's surface. These attractions, produced from dense masses of rock or mountains, cause the plumb-line to deviate from the vertical, and when under ground they alter the oscillations of the pendulum. General Sabine, who made experiments with the pendulum from the equator to within ten degrees of the north pole, discovered that the intensity is augmented by volcanic islands. A variation to the amount of one-tenth of a second in 24 hours can be perfectly ascertained in the rate of the pendulum; but from some of these local attractions a variation of nearly 10 seconds has occurred during the same period. The islands of St. Helena, Ascension, St. Thomas, Mauritius, are some of those noted by General Sabine.

There are other remarkable instances of local disturbance, arising from the geological nature of the soil; for example, the intensity of gravitation is smaller at Bordeaux, from whence it increases rapidly to Clermont-Ferrand, Milan, and Padua, where it attains a maximum (owing probably to dense masses of rock under ground), and from thence it extends to Parma. In consequence of this local attraction, the degrees of the meridian in that part of Italy seem to increase in length towards the equator through a small space, instead of decreasing, as if the earth were drawn out instead of flattened at the poles.

It appears from this that the effect of the whole mass of the globe on a pendulum or torsion balance may be compared with the effect

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pressed in feet or miles, and multiplied by itself, is the square of the sine of the latitude. Gravitation increases from the equator to the poles according to that law, and the length of the degrees augments very nearly in the same ratio.

[1] The inequalities in the motions of the moon and earth are explained in Sections 5 and 11 of the 'Connexion of the Physical Sciences.'

of a small part of it, and thus a comparison may be instituted between the mass of the earth and the mass of that part of it. Now a leaden ball was weighed against the earth by comparing the effects of each upon a balance of torsion; the nearness of the smaller mass making it produce a sensible effect as compared with that of the larger, for by the laws of attraction the whole earth must be considered as collected in its centre. In this manner a value of the mass of the earth was obtained; and, as its volume was known, its mean density was found to be 5·675 times greater than that of water at the temperature of 62° of Fahrenheit's thermometer. Now, as that mean density is double that of basalt, and more than twice that of granite, rocks which undoubtedly have emanated from very great depths beneath the surface, it affords another proof of the increase in density towards the earth's centre. These experiments were first made by Cavendish and Mitchell, and latterly with much greater accuracy by the late Mr. Baily, who devoted four years of unremitted attention to the accomplishment of this important and difficult research.[1]

§ 7. Although the earth increases in density from the surface to the centre, as might naturally be expected from the increasing pressure, yet the surface consists of a great variety of substances of different densities, some of which occur in amorphous masses; others are disposed in regular layers or strata, either horizontal or inclined at all angles to the horizon. By mining, man has penetrated only a very little way; but by reasoning from the dip or inclination of the strata at or near the surface, and from other circumstances, he has obtained a pretty accurate idea of the structure of our globe to the depth of about 10 miles. All the substances of which we have any information are divided into four classes, distinguished by the manner in which they have been formed: namely, plutonic and volcanic rocks, both of igneous origin, though produced under different circumstances; aqueous or stratified rocks, entirely due to the action of water, as the name implies; and metamorphic rocks, originally deposited by water, and consequently stratified, but subsequently altered from their original state and crystallized. The aqueous and volcanic rocks are formed at or near the surface of the earth, the plutonic and metamorphic at greater depths; but all of them have originated simultaneously during every geological period. The antagonistic principles of fire and water have ever been and still are the cause of the perpetual vicissitudes to which the crust of the earth is liable.

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[1] Mr. Airy made a series of experiments to ascertain the mean density of the earth by comparing the simultaneous oscillations of two pendulums, one at the bottom of the Harton Coal Mine in Northumberland, 1260 feet deep, and the other on the surface of the earth perpendicularly above it. The oscillations were compared with an astronomical clock at each station, and the time was instantaneously transmitted from one to the other by a telegraphic wire. The oscillations were observed for more than 100 hours consecutively, when it was found that the lower pendulum made two oscillations more in 24 hours than the upper one. The places of the pendulums were then reversed and the experiment repeated for the same length of time with the same result. The difference in the number of oscillations at the two stations showed that gravitation at the bottom of the mine exceeded that at the surface by the $\frac{1}{19190}$ part, and that the mean density of the earth deduced therefrom was 6·565.

Opinion with regard to the formation of the igneous crystalline rocks by the cooling of fused matter under immense pressure has been greatly modified, chiefly by the experiments of the continental chemists, who have come to the conclusion that water combined with intense heat and pressure must have had an important share in these operations from the most remote geological periods. It has long been known that substances combine chemically with certain portions of water while crystallizing, and that the same substance crystallizing at different temperatures combines with different quantities of water, and assumes a corresponding variety of forms. Now granite and such of the metamorphic rocks as owe their structure to heat and great pressure are highly crystalline, and by numerous synthetic experiments it has been clearly proved that water has been as necessary to their formation as heat and pressure, and that the agency of the aqueous principle begins now to be generally acknowledged. The earthquake, the elevation and disruption of the terrestrial strata, and the torrents of lava that flow from the craters of numerous volcanoes, are sufficient proofs that abundance of water in the state of steam at a high pressure abounds in the interior of the earth.

It has been ascertained that the plutonic rocks, consisting of the granites and some of the porphyries, were formed in the deep and fiery caverns of the earth, of molten matter, which crystallized and combined with water as it slowly cooled under enormous pressure, and was then heaved up in unstratified masses, by the elastic force of the internal heat, even to the tops of the highest mountains, or forced in a semi-fluid state into fissures of the superincumbent strata, sometimes into the cracks of the previously formed granite; for that rock, which constitutes the base of so large a portion of the earth's crust, has not been all formed at once; some portions had been solid, while others were yet in a liquid state. This class of rocks is completely destitute of fossil organic remains.

Although granite and volcanic rocks are both due to the action of fire, their nature and position are very different; granite, fused in the interior of the earth, has been probably cooled to a certain extent before coming to the surface: besides, it consists of few ingredients, so that it has nearly the same mineralogical character in all countries. But as the volcanic fire rises to the very surface of the earth, fusing whatever it meets with, volcanic rocks assume various forms, not only from the varied kinds of strata which are melted, but from the different conditions under which the liquid matter has been cooled, and the different proportions of water with which it combines — circumstances that seem to have had the greatest effect on its appearance and structure. Sometimes it assumes a crystalline granitic structure, at others it becomes vitreous, or like glass; in short, all those massive, unstratified, and occasionally columnar rocks, as basalt, greenstone, certain porphyries, and perhaps serpentine, are due to volcanic action, and are consequently devoid of organic remains.

There seems scarcely to have been any age of the world in which volcanic eruptions have not taken place in some part of the globe. Lava has pierced through every description of rocks, spread over the surface of those existing at the time, filled their crevices, and flowed between their strata. Ever changing its place of action, it has burst out at the bottom of the sea as well as on dry land. Enormous quantities of scoriæ and ashes have been ejected from numberless craters, and have formed extensive deposits in the sea, in lakes, and on the dry land, in which are embedded the remains of the animals and vegetables of the epoch.

There can be no doubt that metamorphic crystalline stratified rocks, such as gneiss, mica-schist, clay-slate, quartz rock, statuary marble, dolomites, &c., were formed of the sediment of water in regular layers, differing in kind and colour, and that they have acquired a crystalline structure, but that the change has been invariably effected in consequence of their proximity to deep-seated fused matter. The term metamorphic has now a more extensive meaning; it is applied to any sedimentary rock that is altered from its original state to a hard or crystalline structure, without reference to any theory by the agency of which the change was produced, however diversified the nature of the rock may be. In fact, Chemical Geology, a recent branch of science, has proved that the term metamorphic, taken in its widest sense, might be applied to every altered rock, be its age or nature what it may. It is possible that highly crystallized strata which extend over thousands of square miles may have occasionally acquired their crystalline character from transmitted heat combined with steam and chemical action under enormous pressure.[1] Mr. Darwin estimated, from the number of volcanoes in simultaneous eruption in the Chilian Andes in the year 1835, that a subterraneous lake of liquid lava twice as large as the Black Sea was in all probability formed under the southern extremity of the American continent, and the internal fire was certainly not less energetic in the early geological eras. An earthy stratum has sometimes been changed into a highly crystallized rock, to a considerable distance from the point of contact, by heat thus transmitted; and there are instances of dark-coloured limestone, full of fossil shells, that has been changed into statuary marble from the same cause. Such alterations may frequently be seen to a small extent on rocks adjacent to a stream of lava.

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[1] The whole question of metamorphism in rocks has been admirably treated in a prize essay presented to the Institute of France by M. Daubrée (*Études sur le Métamorphisme des Roches Crystallines*, Paris, 1859), in

Notwithstanding these instances, it would be a great error to suppose that metamorphism is always connected with internal heat, even in formations of great extent; for it frequently happens that crystalline strata alternate with others of vast thickness through which the heat could not have been transmitted. Those strata could hardly have remained for long geological epochs under the influence of chemical affinity, electricity, and magnetism, which perpetually agitate all the atoms of matter, without assuming a crystalline character, which the intimate and singular connection of these forces with crystallization renders the more probable. Crystals are produced by chemical attraction, and also by electricity; for M. Becquerel formed a great number, precisely the same with those produced in nature, by the long-continued action of weak galvanic electricity upon suitable substances. It may be presumed that occasionally at least, the isolated crystals found in veins and imbedded in the crystalline rocks may be attributed to this cause. The physical forces are really metamorphic, and have an important share in those changes which the formations of all ages seem to undergo; the whole phenomena are extremely complicated, but synthetic chemistry is daily throwing light upon this difficult subject.

There is seldom a trace of organic remains in the crystalline stratified rocks; their strata are sometimes horizontal, but they are usually tilted at all angles to the horizon, and form some of the highest mountains and most extensive table-lands on the face of the globe.

Aqueous rocks are all stratified, being sedimentary deposits from water. They originate in the wear of the land by rain, streams, or the waves of the ocean. The débris carried by running water are deposited at the bottom of the seas and lakes, where they are consolidated, and then raised up by subterranean forces, again to undergo the same process of destruction after a lapse of time. By

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which its author has rendered every justice to the first propagator of the theory, our countryman James Hutton.

the wasting away of the land the lower rocks are laid bare; and, as the materials are deposited in different places according to their weight, the strata are exceedingly varied, but consist chiefly of arenaceous or sandstone rocks, composed of sand, clay, and carbonate of lime. They constitute three great geological divisions, which, in an ascending order, are the primary and secondary fossiliferous strata and the tertiary formations.

The primary fossiliferous or Palæozoic strata, the most ancient of all the sedimentary rocks, consisting of limestones, sandstones, and shales, are entirely of marine origin, having been formed far from land at the bottom of an ocean; consequently they contain the remains of marine animals only, and after the lapse of unnumbered ages even the ripple-marks of the waves are often distinctly visible on the surface of some of their strata. The Palæozoic rocks are subdivided into the Cambrian, and the Lower and Upper Silurian, Devonian, and Carboniferous systems, each distinguished by their peculiar fossil remains.

Recently, indeed, it has been shown by Sir William Logan in Canada, and simultaneously by Sir R. Murchison in the north-western parts of Scotland, that there exists a sedimentary system of strata of older date than the Cambrian and Silurian rocks. Stratified masses, now for the most part in the state of gneiss, yet containing numerous interpolations of schistose, silicious, calcareous beds, associated with many granitic and hornblendic rocks, are seen in the Laurentian mountains of British North America to rise up from beneath all the Huronian (Cambrian) and Lower Silurian deposits, and hence Sir W. Logan assigned to them the name of Laurentian. Discovering a similar infraposition on the west coasts of Sutherland and Ross, including the great island of Lewis, Sir R. Murchison, terming these rocks Fundamental Gneiss, demonstrated that they were clearly overlaid by sandstone and conglomerates, with an entirely different strike (Cambrian), and that the latter were followed by crystalline schists and limestone, containing Lower Silurian fossils. The separation of this fundamental or Laurentian gneiss from all the younger schistose, quartzose, and occasionally gneissose strata of the central and eastern highlands of Scotland, which are the metamorphosed equivalents of the Silurian rocks, is one of the most important additions to our acquaintance with the history of the succession of geological formation which has been made in the present day.[1]

In the Cambrian rocks, upwards of 20,000 ft. thick, no other organic remains are known except a rare zoophyte, a doubtful trilobite, and traces of sea-worms; but the Silurian rocks abound in them more and more as the strata lie higher in the series; the whole being characterised by the serrated zoophytes called Graptolites. A discovery of animal remains of remarkable interest has, however, recently been made in the lowest beds of the Laurentian system, and therefore far beneath the oldest of the hitherto-known fossiliferous formations. These remains belong to the Eozoon Canadense, a form low in the scale of organization, and found in great abundance in Canada. In the lower Silurian group are the remains of shells, almost all of extinct genera; and the few that have any affinity to those alive are of extinct species. Crinoidea, or stone lilies, which had been fixed to the rocks like tulips on their stems, are coeval with some of the earliest inhabitants of the deep; and the trilobite, a jointed creature of the crab kind, with prominent eyes, is almost exclusively confined to the Silurian strata, but the last traces of it are found in the Carboniferous limestone above. In the Upper Silurian group are abundance of marine shells of almost every order, together with crinoidea, vast quantities of corals, and some sea-weeds: several small and very peculiar fishes, of extinct genera, but of a high organization, have been found in the highest beds—the only vertebrated animals that have yet been discovered among the countless profusion of the lower orders of animals that are entombed in the primary fossiliferous strata. The remains of one or more land-plants, in a very imperfect state, are said to have been found in the Silurian rocks of North America, which shows that there had been dry land with vegetation at that early period.[1] The type of these plants, as well as the size of the shells and the quantity of the corallines, indicate that a uniformly warm temperature then prevailed over the globe. During the Silurian period an ocean covered the northern hemisphere, islands and lands of moderate size had begun to rise from beneath its waters, and earthquakes, with volcanic eruptions from insular and submarine volcanoes, were frequent towards its close.

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[1] See 'Quarterly Journal Geological Society;' and 'New Geological Map of Scotland,' by Murchison and Geikie (A. Keith Johnston, Edinburgh).

The younger palæozoic strata, which comprise a great geological period, and constitute a principal part of the high land of Europe, were deposited at the bottom of an ocean, like the primary, from the débris of all the others, carried down by water, and still bear innumerable tokens of their marine origin. Calcareous rocks are more abundant in these strata than in the crystalline, probably because the carbonic acid was then, as it still is, driven off from the lower strata by internal heat, and came to the surface as gas or in calcareous springs, which either rose in the sea and furnished materials for shell-fish and coral animals to build their habitations and form coral reefs, or deposited their calcareous matter on the land in the form of rocks.

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[1] According to Sir R. Murchison, the highest authority upon this class of formations, no unequivocal terrestrial plants or vertebral animals (*i. e.* fishes) have been found in strata older than the youngest Silurian, or the Ludlow rocks, where the Silurian begin to pass into the Devonian beds, in which land-plants and fishes abound.

The Devonian or old Red Sandstone group,[1] in many places 10,000 feet thick, consisting of strata of conglomerates, dark red and other sandstones, marls, coralline limestones, &c., forms a link between the Silurian and Carboniferous rocks, by a resemblance in their fossil remains. It has fossils peculiarly its own, whilst others are common to the strata both above and below it. There are various species of extinct fishes in this group, some of which were of gigantic size, others had strong bony shields on their heads, and one covered with osseous scales had fins or appendages like wings. The sharks approach nearer to some of these ancient fishes than any other now living.[2]

During the long period of tranquillity that prevailed after the Devonian group was deposited, a very hot, moist, and extremely equable climate, which extended all over the globe, had clothed the islands and lands in the ocean then covering the northern hemisphere with luxuriant tropical forests and jungles. Subsequent inroads of fresh water, or of the sea, or rather partial sinkings of the land, had submerged these forests and jungles, which, being covered with layers of sand and mud, had in time been consolidated into one mass, and were then left dry by the retreat of the waters, or, more probably, raised above the surface by internal forces.

These constitute the remarkable group of the Carboniferous system, which consists of strata of limestones, shales, and sandstones, filled with a prodigious quantity of the remains of fossil land-plants, intermixed with beds of coal, which is entirely composed of vegetable matter. In some cases the plants appear to have been carried down by floods, and deposited in estuaries near the mouths of rivers; but in most instances the beauty and delicacy of their impressions show that they had grown near to the spot where the coal was formed. More than 300 species of fossil plants have been collected from the strata where they abound, frequently with their seeds and fruits, so that enough remains to show the peculiar nature of this flora, whose distinguishing feature is the preponderance of monocotyledonous plants; among these there were tree-ferns of 40 and 50 feet high. There were also plants resembling the fox-tail tribe (equisetum), of gigantic size; others like the tropical club mosses; besides others, to which we have nothing now living analogous. Coniferous trees of great magnitude, of the pine and fir tribes, flourished at that period. The remains of an extinct araucaria, one of the largest of the pine family, have been found in the British coal-fields; the existing species now grow in countries of the southern hemisphere; a few rare instances occur of grasses, palms, and liliaceous plants. The botanical districts were very extensive when the coal-plants were growing, for some species are nearly identical throughout the coal-fields of Europe and America. From the extent of the ocean, the insular configuration of the land, the profusion of ferns and fir-trees, and the warm, moist, and equable climate, the northern hemisphere, during the formation of the coal strata, very probably bore a strong resemblance to that of the South Pacific, with its fern and fir clothed lands of New Zealand, Kerguelen Land, &c. &c.

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[1] The name of Devonian was given to the rocks of this group by Murchison and Sedgwick, because the calcareous strata of Devonshire contain fossils which are unknown in the more arenaceous parts of the old Red Sandstone, and indicate an intermediate period between the Silurian and Carboniferous systems. The Devonian rocks are represented on the Continent by the schistose fossiliferous rocks of the gorges of the Rhine, and in Russia by others containing the shells of Devonshire and the fossil fishes of the old Red Sandstone of Scotland.—See Murchison's Siluria.

[2] The old Red Sandstone of Scotland, where it is remarkably well developed, has been admirably illustrated in three works by one of our most industrious and talented northern geologists, the late Mr. Hugh Miller. See 'Old Red Sandstone,' the 'Footprints of the Creator,' 1 vol. 12mo., 1850, and 'Testimony of the Rocks,' 1 vol. 12mo., 1857, published after the death of its lamented author.

The marine remains of the Carboniferous period are found chiefly in the mountain limestone, a rock which in some countries lies beneath the coal-measures, or sometimes alternates with their shales and sandstones. They consist of crinoidea and marine testaceæ, among which the size of the chambered shells, as well as that of the corals, shows that the waters of the ocean were then very warm, even in the high northern latitudes. The footsteps of a very large reptile allied to the frog family have been found on some of the Carboniferous strata of North America. In many countries, as in Scotland, Russia, and Turkey, the coal-beds are in the Carboniferous limestone.

The coal strata have been very much broken, deranged, and dislocated in many places by earthquakes and igneous eruptions, producing faults or dykes, and basaltic veins, which frequently occurred also during the secondary fossiliferous period, and from time to time raised islands and land from the deep. The older rocks are more shattered by earthquakes than the newer, because the movement came from below; but these convulsions have never extended all over the earth at the same time: for example, the

Silurian strata have been dislocated and disturbed in Britain, while throughout a vast area in Russia they still retain a horizontal position. There is no proof within the historical period that any entire mountain-chain has ever been raised by great upheavals, although it is generally admitted by our soundest geologists that such took place at remoter periods, with long intervals of ordinary quiescent action, and that by this means the great mountain-ridges of our globe have attained their present position: the contrary opinion, which has for its advocate Sir C. Lyell, will only admit that the elevation has been produced by a long-continued and reiterated succession of small internal movements with intervals of repose. In some rare instances the land has been raised up or sunk down by an equable motion continued for ages, while in other places the surface of the earth has remained stationary for long geological periods.

The Permian system of Murchison comes immediately above the coal measures, and consists of breccias or conglomerates, gypsum, sandstones, marls, &c.; its distinguishing feature in England is a yellow limestone rock, containing a considerable proportion of carbonate of magnesia, which often assumes a granular texture, under which form it is known as Magnesian Limestone or Dolomite. The Permian formation has a flora and fauna peculiar to itself, approaching to those of the coal strata. Here the remnant of an earlier creation gradually tends to its final extinction. The flora is to some extent analogous to that in the coal strata below. Upwards of fifty species of fossil fishes are found in this formation, all belonging to genera known in the Carboniferous epoch; and several saurian reptiles,[1] which Owen refers to a higher order than any in the subjacent strata, some of which may have even lived upon dry land.

At the close of the Permian period all the Palæozoic animals disappeared, and an entirely new creation followed in the next series, called the Trias, consisting of red marls, rock-salt, and sandstones, which have been produced by the disintegration of metamorphic slates and porphyritic rocks, and are known as the trias, or new red sandstone formation; the trias lies above the magnesian limestone. In England this formation is particularly rich in rock-salt, which, with beds of gypsum and marl, is sometimes 600 feet thick; but the Muschelkalk, a peculiar kind of shelly limestone, is wanting, whilst in Germany and on the southern declivity of the Alps it is remarkable for the quantity of its organic remains. At this time creatures like frogs, of enormous dimensions, were frequent, as they have left their footsteps on what must then have been a soft sea-beach. Numerous genera of fossil animals have been found in the trias in Germany, consisting of shells, cartilaginous fishes, encrinites, &c., all distinct in species, and many in genera, from those of the subjacent magnesian limestone, and also from those entombed in the strata above.

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[1] Saurian reptiles are crocodiles, lizards, iguanas, &c.

During a long period of tranquillity the Oolitic or Jurassic group was next deposited in a sea of variable depth, and consists of sands, sandstones, marls, clays, and limestones. At this time there was a complete change in the aqueous deposits all over Europe. The red iron-stained arenaceous rocks, the black coal, and dark strata, were succeeded by light-blue clays, pale-yellow limestones, and, lastly, white chalk. The water that deposited these strata must have been highly charged with carbonate of lime, since few of the formations of that period are without calcareous matter, and calcareous rocks were formed to a prodigious extent throughout Europe: the Pyrenees, Alps, Apennines, and Balkan abound in them; and the Jura mountains, which have given their name to the series, are chiefly formed of them. The European ocean then teemed with animal life; whole beds consisting almost entirely of marine shells and corals. Belemnites and Ammonites, from an inch in diameter to the size of a cart-wheel, are entombed by myriads in the strata; whole forests of that beautiful Encrinite, the stone-lily, flourished on the surface of the oolite, then under the waters; and the Pentacrinite, one of the same family, is embedded in millions in the lias, which occupies such extensive tracts in Europe. Fossil fishes are numerous in the oolitic strata, but different from those of the carboniferous, permian, and triassic series. The newly-raised islands and lands were clothed with vegetation like that of the large islands of the intertropical archipelagos of the present day, which, though less rich than during the carboniferous period, still indicate a very moist and warm climate. Ferns were less abundant; they were associated with various genera and species of the cycadeæ, which had grown on the southern coast of England, and in other parts of northern Europe, as they now do with the cycas and zamia of the tropics. The pandanus, or screw-pine, the first tenant of new lands in ancient and modern times, belongs to a family found in a fossil state in the inferior oolite of England, which was but just rising from the deep at that time. The species now flourishing grows only on the coasts of such coral islands in the Pacific as have recently emerged from the waves. In the upper strata of this group, however, the confervæ and monocotyledonous plants[1] become more rare—an indication of a change of climate.

The new lands that were scattered above the ocean of the oolitic period were drained by rivers, and inhabited by crocodiles and other saurians of gigantic size, mostly of extinct genera. A recent discovery has also shown that birds of a primitive type existed at this epoch. The remains of a strange form, named Archeopteryx, were first found in 1861, in the lithographic slate of Solenhofen; subsequently a nearly perfect skeleton was discovered and obtained for the collection of the British Museum. The chief peculiarity of this early form of bird is that the tail is elongated as in lizards, consisting of 20 vertebræ, with feathers on each side along the whole length, one pair to each vertebra. The crocodiles of the oolitic period come nearest to living reptiles; but the others, though bearing a similitude in general structure to recent forms, were quite anomalous, combining in one the structure of various distinct creatures, and so monstrous that they must have been more like the visions of a troubled dream than things of real existence; yet in organisation a few of them came nearer to the type of living mammalia than any existing reptiles do. Some of these had lived in rivers, others in the ocean—some were inhabitants of the land, others were amphibious; and the several species of one genus even had wings like a bat, and fed on insects. There were both herbivorous and predaceous saurians; and from their size and strength they must have been formidable enemies to their neighbours. Besides, the numbers deposited are so great, especially in the lias, a marine formation of clay and limestone, which forms the lowest portion of the oolitic series, that they must have swarmed for ages in the estuaries and shallow seas of the period. They gradually diminished in number towards the end of the secondary fossiliferous epoch; but as a class they lived in all subsequent eras, and some, as the crocodiles, still exist in tropical countries, although the species are very different from their ancient congeners. Tortoises of various kinds—also a family that still exists—were contemporary with the saurians. In the Stonefield slate, a stratum of the oolitic group, there are the remains of insects, and the bones of four small quadrupeds have been found there belonging to the marsupial tribe,[1] like the opossum—a very remarkable circumstance, not only as being the most ancient animal of the class of mammalia, but because that family of animals at the present time is confined to Australia, the two Americas, as far north as Pennsylvania—and higher up in the oolitic series, in the Purbeck beds of Dorsetshire, as many as fourteen species of predaceous and insectivorous mammalia, allied to the beautiful kangaroo-rat of Australia. The great changes in animal life are indications of the successive alterations that had taken place during this period on the earth's surface.

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[1] Confervæ are plants with nearly imperceptible fructification, found in ponds, damp places, and in the sea. Monocotyledonous plants are grasses, palms, &c. &c., so called from having only one seed-lobe.

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[1] Marsupial animals have pouches in which their young take refuge and are nourished till they attain a certain development. The opossum and kangaroo are marsupials.

The cretaceous strata follow the oolite in the ascending order, consisting of clays, green and iron sands, blue limestone, and chalk, probably formed of the débris of coral and shells, which predominates so much in England and other parts of Europe that it has given the name and its peculiar feature to the whole group. It is, however, by no means universally distributed; the chalk is wanting in many parts of the world where the other strata of this series prevail, and then their connection with the group can only be ascertained by the identity of their fossil remains. With the exception of some beds of coal in the oolitic series, the Wealden clay, the lowest of the cretaceous group in England, is the only fresh-water formation, and the tropical character of its flora shows that the climate was still very warm. Plants allied to the zamias and cycadeæ of our tropical regions, many ferns and conifers of the genus araucaria, characterised its vegetation. It was inhabited by tortoises approaching to forms that now live in warm countries, and saurian reptiles of several different genera swarmed in the lakes and estuaries. This clay contains fresh-water shells and fish of the carp kind.

The cretaceous strata above our Wealden clay are full of marine remains. There are vast tracts of sand in Northern Europe, and many very extensive tracts of chalk; but in the southern part of the Continent the cretaceous rocks assume a different mineralogical character. There and elsewhere extensive limestone rocks, filled with very peculiar shells, show that, when the cretaceous strata were forming, an ocean extended from the Atlantic into Asia, which covered the south of France, all southern Europe, part of Syria, the isles of the Ægean Sea, the coasts of Thrace and the Troad. The remains of turtles have been found in the cretaceous group, quantities of coral, and abundance of shells of extinct species; some of the most minute species of microscopic shells, or Foraminifera, which constitute a large portion of the chalk, have great analogy with creatures now alive, the Globigerinæ, forming the first approach to an identity of species in the ancient and modern creation. An approximation to recent modes of distribution is to be observed also in the arrangement of organised nature, since at this early period, and even in the Silurian and oolitic epochs, the marine fauna was divided, as now, into distinct geographical provinces. The great saurians were on the decline, and many of them were found no more, but a gigantic creature, allied to the monitor and iguana,[1] lived at this period. From the trias to the chalk inclusive only two instances of fossil birds, besides the Archeopteryx, are cited, one in a chalk deposit in the Swiss Alps, and the other, a kind of albatross, in the chalk of England; in North America, however, foot-marks of a variety of birds have been found in the strata between the coal and lias, some of which are larger than those of the ostrich.

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[1] The monitor and iguana, creatures of the lizard tribe, still existing.

It was formerly supposed that a great geological cycle had elapsed between the termination of the secondary fossiliferous strata and the beginning of the tertiary, but later researches, especially of Sir R. Murchison, have shown that the break was not so extensive as had been supposed, and that passages from the chalk to the lower tertiary beds were by no means unfrequent along the southern declivity of the Alps through the well-known beds of the nummulitic series. With the tertiary, however, a new order of things may be said to commence, approaching more closely to the actual state of our globe. During the tertiary period the same causes under new circumstances produced an infinite variety in the order and nature of the strata, accompanied by a corresponding change in animal and vegetable life. The old creation, which had little in common with the existing order of things, had passed away, and given place to one more nearly approaching to that which now prevails. Among the myriads of beings that inhabited the earth and the ocean during the secondary fossiliferous epoch scarcely one species is to be found in the tertiary. This break in the law of continuity is the more remarkable, as hitherto some of the newly-created animals were generally introduced before the older were extinguished. The circumstances and climate suited to the one became more and more unfit for the other, which consequently perished gradually, while their successors increased.[1]

The series of rocks, from the granite to the end of the secondary fossiliferous strata, taken as a whole, constitute the solid crust of the globe, and in that sense are universally diffused over the earth's surface. The tertiary strata for the most part occupy the hollows formed in this crust, whether by subterraneous movements, by lakes, or denudation by water as in the estuaries of rivers, and consequently occur in irregular tracts, often, however, of very great thickness and extent.

The innumerable basins and hollows with which the continents and larger islands had been indented for ages after the termination of the secondary series had sometimes been fresh-water lakes, and at other times inundated by the sea; consequently, the deposits which took place during these alternate changes contain the spoils of both terrestrial and marine animals. The frequent intrusion of volcanic strata among the tertiary strata shows that, in Europe, the earth had been in a very disturbed state, and that these repeated vicissitudes had been occasioned by elevations and depressions of the soil, as well as by the action of water.

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[1] A break, in no degree less remarkable than that between the chalk and the tertiary strata, exists at the base of the secondary series, between the Permian and the Triassic series.

There are three distinct groups in these strata; the lowest tertiary or Eocene group, so called by Sir Charles Lyell, because, among the myriads of fossil shell-fish which it contains, very few are identical with those now living; the Miocene, or middle group, has a greater number of the exuviæ of existing species of shells; and the Pliocene, or upper tertiary group, a still larger proportion. Though frequently heaved up to great elevations on the flanks of the mountain-chains, as, for example, in the Alps and Apennines, often assuming a vertical stratification, a part of the tertiary strata maintain their original horizontal position in the places where they were deposited. Immense insulated deposits of this kind are to be met with all over the world; Europe abounds with them; London, Paris, Rome, and Vienna stand on such strata; and they cover immense tracts both in North and South America.

The gigantic reptiles had mostly disappeared, and mammalia, of forms scarcely less anomalous, though approaching more nearly to animals now living, took possession of the earth.

Numerous species of extinct animals, of the order of Pachydermata,[1] that lived during the earliest or Eocene period, and to the greater number of which we have nothing analogous, have been found in various parts of the world, especially in the Paris basin; they were mostly herbivorous quadrupeds, which frequented the borders of the rivers and lakes that covered the greater part of Europe at that time. This is the more extraordinary, as existing animals most similar to them, the tapirs for instance, are confined to the tropical countries. These creatures were widely diffused, and some of them were associated with genera still existing, though of totally different species; such as animals allied to the racoon and dormouse, the ox, bear, deer, the fox, the dog, &c., &c. Although these quadrupeds differ from those of the present day, the same proportion existed then as now between the carnivorous and herbivorous genera. Remains of marine mammalia[2] of this period have also been found, sometimes at great elevations above the sea, all of extinct species; some of these cetacea were of huge size. This marvellous change in the living creation was not confined to the earth and the ocean; the air also was now occupied by many extinct races of birds allied to the owl, buzzard, quail, curlew, &c. The climate must still have been warmer than at present, from the remains of land and sea plants allied to those now growing in equatorial latitudes. Even in England bones of the opossum, monkey, crocodile, and boa have been discovered, animals of warmer latitudes, beside a sword and saw fish, both genera at present foreign to the British seas.

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[1] Pachydermata, thick-skinned animals, as the rhinoceros, hog, elephant, tapir, and hippopotamus.

[2] Marine mammalia, which suckle their young like land animals, are seals, walruses, whales, porpoises, &c.

During the Miocene period new amphibious quadrupeds were associated with the old, of which the Dinotherium is the most remarkable, and one of the largest of the mammalia yet found, of a singular form, and surpassing the elephant in size.

The Palæotherium belonged to this period, and also the huge Mastodon. Various families, and even genera, though no species, of quadrupeds now existing were associated with these extraordinary creatures, such as the elephant, rhinoceros, hippopotamus, tapir, horse, bear, wolf, hyæna, weasel, beaver, ox, buffalo, deer, &c.; and also marine mammalia, as seals, dolphins, walruses, and lamantins. Indeed, in the constant increase of animal life manifested throughout the whole of the tertiary strata, the forms approach nearer to the living ones the higher their remains lie in the series.

In the older Pliocene period some of the large amphibious quadrupeds, and other genera of mammalia of the earlier tertiary periods, cease to appear; but there we find the mastodon, and the Elephas primigenius or mammoth, besides other species of elephant, of prodigious size, which were associated with numerous quadrupeds of existing genera, but lost species. Extinct species of many genera of quadrupeds, now living, inhabited the earth at that time; their bones have been discovered in caverns, enveloped in calcareous breccia or embedded in most of the strata of the epoch—as the hippopotamus, rhinoceros, elephant, horse, bear, wolf, water-rat, hyæna, tiger, and several birds. It is remarkable that in Australia the fossil bones all belong to gigantic species of genera of kangaroos and wombats, animals of the marsupial family, which are so peculiarly the inhabitants of that country at the present day. The newer Pliocene strata show that the same analogy existed between the extinct and recent mammalia of South America, both, with few exceptions, belonging to that continent alone; for the fossil remains, quite different from those in the old world, are of animals of the same families with the sloths, ant-eaters, and armadilloes which now inhabit that country, but of vastly superior size. In fact, there were giants in the land in those days. Were changes of species admitted, one might almost fancy that these countries had escaped the wreck of time, and that their inhabitants had dwindled under the change of circumstances. The megatherium and Equus curvidens, or extinct horse, had so vast a range in America, that, while Sir Charles Lyell collected their bones in Georgia in 33° N. latitude, Mr. Darwin brought them from the corresponding latitude in South America. The Equus curvidens differed as much from the living horse as the quagga or zebra does, and the fossil horse found in Europe is also probably a distinct and lost species.

A comparison of the fossil remains with the living forms has shown the analogy between these beings of the ancient world and those that now people the earth; and the greatest triumph of the naturalist is the certainty with which he can decide upon the nature of animals that have been extinct for thousands of years, from a few bones entombed on the earth's surface. Cuvier will ever be celebrated as the founder of this branch of comparative anatomy, which Professor Owen, in our own country, and following in his steps, has so much extended. Among many other important discoveries, he has found, by microscopic observation, that the structure of the tissue of which teeth are formed is different in different classes of animals, and that the species can in many instances be determined from the fragment of a tooth. A small portion of a bone enabled him to decide on the nature of the extinct race of gigantic birds which formerly inhabited New Zealand, and the subsequent discovery of the entire skeleton confirmed the accuracy of this determination.

The greater part of the continents in the northern hemisphere was elevated above the deep during the tertiary period, and such lands as already existed acquired additional height; consequently the climate, which had previously been warm and equable, became gradually colder, for an increase of land, which raises the temperature between the tropics, has exactly the contrary effect in higher latitudes. To this cause, and especially to the increase of land in and near the arctic circle, may be attributed, perhaps, the greater degree of cold that appears to have prevailed during the latter part of the Pliocene period, when a large extent of the European continent was covered by an ocean full of floating ice, not unlike that seen at this day off the north-eastern coast of America.[1]

During the latter part of the Pliocene period, however, the bed of that glacial ocean rose partially, and after many vicissitudes the European continent assumed nearly its present form. There is every reason to believe that the glacial sea extended also over great portions of the arctic lands of Asia and America. Old forms of animal and vegetable life were destroyed by these alterations in the surface of the earth, and the consequent change of temperature; and when, in the progress of the Pliocene period, the mountain-tops appeared as islands above the water, they were clothed with the flora and peopled by the animals they still retain; and new forms were added as the land rose and became dry and fitted to receive and maintain the races of animals now alive, all of which had possession of the earth for ages prior to the commonly received historical or human period. Some of the extinct animals had long resisted the great vicissitudes of the times; of these the species of Elephant whose remains are found all over Europe, Asia, and America, but especially in the frozen soil of Siberia, alone outlived its associates, the last remnant of a former world. In two or three instances this animal has been discovered entire, entombed in frozen mud, with its hair and flesh so fresh that wolves and dogs fed upon it. The globe of the eye of one found by M. Middendorf at Tas, between the rivers Oby and Jenesei, was so perfect that it is now preserved in the museum at Moscow. It has been supposed that, as the Siberian rivers flow for hundreds of miles from the southern part of the country to the Arctic Ocean, these elephants might have been drowned by floods while browsing in the milder regions, and that their bodies were carried down by the rivers and embedded in mud, and frozen before they had time to decay. Mr. Darwin has suggested that, if the climate of Siberia has at any time been similar to that of the high latitudes of South America, where the line of perpetual snow in the Andes, and its sudden flexure in Southern Chile, come close to a nearly tropical vegetation, such a vegetation may have prevailed south of the frozen regions in Siberia. On the other hand, although the living species of this animal are now inhabitants of the torrid zone, they may have been able to endure the cold of a Siberian winter; for Cuvier has shown that the fossil differed as much from the living elephant as the horse does from the ass. Mr. Darwin supposes that the supply of food in summer was probably sufficient, since the quantity requisite for the maintenance of the larger animals is by no means in proportion to their bulk; or these elephants may have migrated to a more genial climate in the colder months.

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[1] If a line be drawn from the north-eastern coast of North America within the limit of floating ice, and if it be continued across the southern half of Ireland and England, and prolonged eastward so as to strike against the Ural mountains, it will mark the boundary of the European portion of the Glacial Sea. It submerged part of Russia to the depth of 1000 feet.—Essay on the British Fauna and Flora, by Professor E. Forbes, in the 'Memoirs of the Geological Survey of Great Britain,' vol. i.

Shell-fish seem to have been more able to endure all the great geological changes than any of their organic associates, but they show a constant approximation to modern forms during the progress of the tertiary period. The whole of these strata contain enormous quantities of shells of extinct species; in the oldest, 3½ per cent. of the shells are identical with species now existing, while in the uppermost strata of this great geological period there are not less than from 80 to 95 in 100 identical with those now living in the surrounding seas.[1]

Of all the fossil fishes, from the uppermost Silurian strata to the end of the tertiary, scarcely one is specifically the same with living forms. In the Eocene strata one-third belong to extinct genera.

Under the vegetable mould in every country there is a mass of loose sand, gravel, and mud, called alluvium, lying upon the subjacent rocks, often of great thickness, which in the high latitudes of North America and Europe is mixed with enormous fragments of rock, sometimes angular, and sometimes rounded and water-worn, which have been transported hundreds of miles from their origin. It is known as the Boulder formation, or Northern Drift: from the identity of its rolled masses with the rocks of the northern mountains, they evidently have been derived from them, and their size becomes less as the distance increases. In Russia there are blocks of great magnitude that have been carried 800 and even 1000 miles in a south-eastern direction from their origin in the Scandinavian range. There is reason to believe that such masses, enormous as they are, have been transported by icebergs, and deposited when the northern parts of the continents were covered by the glacial sea, by which part of Russia was submerged to the depth of at least 1000 feet. The same process is now in progress in the high southern latitudes, where icebergs have been met covered with fragments of rock and boulders.[2]

The last manifestation of creative power, with few exceptions, differs specifically from all that preceded it; the recent strata contain only the exuviæ of animals now living, often mixed with the works of man.

The solid earth thus tells us of mountains washed down into the sea with their forests and inhabitants; of lands raised from the bottom of the ocean, loaded with the accumulated spoils of centuries; of torrents of water and torrents of fire. In the ordinances of the heavens no voice declares a beginning, no sign points to an end; in the bosom of the earth, however, the dawn of life appears, the time is obscurely marked when the first living things moved in the waters, when the first plants clothed the land. There we see that during ages of tranquillity the solid rock was forming at the bottom of the ocean, that during ages it was tossed and riven by fire and earthquake. What years must have gone by since that ocean flowed which has left its ripple-marks on the sand, now a solid mass on the mountain—since those unknown creatures left their foot-prints on the shore, now fixed by time on the rock for ever! —time, which man measures by days and years, nature measures by thousands of centuries.

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[1] According to Sir C. Lyell, the Pliocene deposits of England (the Norwich, Red, and Coralline Crags) contain respectively, and in the descending order, 80, 57, and 51 per cent. of species still living, most of which belong to the British seas.

[2] Sir James Ross and Captain Wilkes fell in with icebergs covered with mud and stones in the antarctic seas, even in 66° 5′ lat. One block seen by Sir James Ross was estimated to weigh many tons.

The thickness of the fossiliferous strata from their first appearance to the end of the tertiary formation has been estimated at from seven to eight miles; so that the time requisite for their deposition must have been immense. Every river carries down mud, sand, or gravel, to the sea: the Ganges and Brahmapootra united are calculated to bring 6,368,077,440 cubic feet of solid matter every hour into the Bay of Bengal,[1] the Indus 5,866,000,000, and the Mississippi 3,702,758,400; yet, notwithstanding these great deposits, the Italian hydrographer Manfredi has estimated that, if the sediment of all the rivers on the globe were spread equally over the bottom of the ocean, it would require 1000 years to raise its bed one foot; so that at that rate it would require 3,960,000 years to raise the bed of the ocean alone to a height nearly equal to the thickness of the fossiliferous strata, or 7½ miles, not taking account of the waste of the coasts by the sea itself: but if the whole globe be considered, instead of the bottom of the sea only, the time would be nearly four times as great, even supposing as much alluvium to be deposited uniformly both with regard to time and place, which it never is. Besides, in various places the strata have been more than once carried to the bottom of the ocean, and again raised above its surface by subterranean fires after many ages, so that the whole period from the beginning of these primary fossiliferous strata to the present day must be great beyond calculation. These great periods of time correspond wonderfully with the gradual increase of animal life and the successive creation and extinction of numberless orders of being, and with the incredible quantity of organic remains buried in the crust of the earth in every country on the face of the globe.

Every great geological change in the nature of the strata was accompanied by the introduction of a new race of beings, and the gradual extinction of those previously existing, their structure and habits being no longer fitted for the altered circumstances in which these changes had placed them. These changes, however, were never abrupt; and it may be observed that there is no proof of progressive development of species by generation from a low to a higher organization, for animals and plants of high organization appeared among the earliest of their kind, yet throughout the whole the gradual approach to existing and more perfect forms is undoubted, not by the conversion of one species into another, but by increasing similarity of type.

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[1] Lyell, 'Principles of Geology,' 10th Edition., vol. I., pp. 458, 481; Tremenheere, 'Journal of the Royal Geographical Society,' vol. xxxvii., p. 70.

The geographical distribution of animated beings was much more extensive in the ancient seas and land than in later times. In very remote ages the same animal inhabited very distant parts of the sea; the corallines built from the equator to within 10 or 15 degrees of the poles; and previous to the formation of the carboniferous strata there appears to have been even a greater uniformity in the vegetable than in the animal world, though Australia had formed even then a peculiar district, supposing the coal in that country to be of the same age as in Europe and America; but as the strata became more varied, species were less widely diffused. Some of the saurians were inhabitants of both the Old and New Worlds, while others lived in the latter only. During the tertiary period the animals of Australia and America differed nearly as much from those of Europe as they do at the present day. The globe was then, as it is now, divided into great physical regions, each inhabited by peculiar races of animals; and even the different species of mollusca of the same sea were confined to certain localities. Of more than 400 species of the latter which inhabited the Atlantic Ocean during the early and middle parts of the tertiary period, little more than a fortieth part were common to the American and European coasts. In fact, the divisions of the animal and vegetable creation into geographical districts had been in the latter periods contemporaneous with the rise of the land, each portion of which, as it rose above the deep, had been clothed with a vegetation and peopled with creatures suited to its position with regard to the equator, and to the existing circumstances of the globe; and the marine creatures had, no doubt, been divided into districts at the same periods, because the bed of the ocean had been subject to similar changes.

The quantity of fossil remains is so great that, with the exception of the metals and some of the primary rocks, probably not a particle of matter exists on the surface of the earth that has not at some time formed part of a living creature. Since the commencement of animated existence, zoophytes have built coral reefs extending hundreds of miles, and mountains of limestone are full of their remains all over the globe. Mines of shells are worked in some countries to make lime; ranges of hills and rocks, many hundred feet thick, are almost entirely composed of them, and they abound in every mountain-chain throughout the earth. The prodigious quantity of microscopic shells discovered by M. Ehrenberg is still more astonishing; some not larger than a grain of sand form plains at the bottom of the ocean and entire mountains above its surface; a great portion of the hills of San Casciano, and of other tertiary districts in Tuscany, consist of chambered shells so minute that Soldani collected 10,454 from one ounce of stone. Chalk is often almost entirely composed of them.

The facility with which many clays and slates are split is owing, in some instances, to layers of minute shells. Fossil fishes are found in all parts of the world, and in all the fossiliferous strata with the exception of some of the lowest, but each great geological period has species peculiar to itself.

The remains of the great saurians are innumerable; those of extinct quadrupeds are very numerous; but there is no circumstance in the whole science of Palæontology more remarkable than the multitudes of fossil elephants that are found in Siberia. Their tusks have been an object of traffic in ivory for centuries, and in some places they have lain in such prodigious quantities that the ground is tainted with the smell of animal matter. Their huge skeletons are found from the frontier of Europe through all Northern Asia to its extreme eastern point, and from the foot of the Altaï Mountains to the shores of the Frozen Ocean, a surface equal in extent to the whole of Europe. Some islands in the Arctic Sea, as, for instance, in the Lächow group, are chiefly composed of their remains, mixed with the bones of various other animals of extinct species.[1]

Equally wonderful is the quantity of fossil plants that still remain, if it be considered that, from the frail nature of many vegetable substances, multitudes must have perished without leaving a trace behind. The vegetation that covered the terrestrial part of the globe previous to the formation of the carboniferous strata far surpassed in exuberance the rankest tropical jungles at the present day. There are many coalfields of great extent in various parts of the earth, especially in North America, where that of Pittsburg occupies an area of about 14,000 square miles, and that in the State of Illinois is not much inferior to the area of all England.

As coal is entirely a vegetable substance, some idea may be formed of the richness of the ancient flora; in later times it was less exuberant, and never has again been so luxuriant, probably on account of the decrease of temperature during the deposition of the tertiary strata, and in the glacial period which immediately preceded the creation of the present tribes of plants and animals.

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[1] Lieut. Anjou's 'Polar Voyage.'

Even after their introduction the temperature must have been very low, but by subsequent changes in the distribution of the sea and land the cold was gradually mitigated, till at last the climate of the northern hemisphere became what it now is.

Such is the marvellous history laid open to us on the earth's surface. Surely it is not the heavens only that declare the glory of God—the earth also proclaims His handiwork!

Of late years, well-authenticated discoveries have given every reason to believe that a race of mankind peopled various parts of Europe during the post-pliocene period, and were coexistent with the animals of that remote geological era. About twenty years ago M. Boucher de Perthes published an account of flint weapons, evidently the work of man, that he had found mixed with the bones of extinct quadrupeds in an excavation near Abbeville in France, a circumstance that remained unnoticed till subsequent discoveries turned the attention of geologists to the subject. In 1858 Dr. Falconer found implements of human workmanship mixed with the bones of extinct species of quadrupeds in a cavern at Brixham in Devonshire; and during the year 1859 a number of flint hatchets mingled with the bones of extinct animals were dug up by geologists in a post-pliocene deposit that never had been disturbed at St. Acheul near Amiens, and also at Abbeville. Since then numerous other discoveries have been made of unpolished stone implements, buried in ancient river gravels, and in the mud and stalagmite of caves, and associated with remains of the mammoth, the woolly-haired rhinoceros, the hippopotamus, the musk ox, and many other quadrupeds of extinct and living species. The river gravels in which these rude implements are found embedded now lie in some places at a height of 100 or even 200 feet above the present alluvial plains; their antiquity must be measured therefore by the time required for the existing rivers to have scooped out their valleys to this depth, since they were entombed. Still more wonderful is the discovery, since 1864, of these so-called Palæolithic implements in masses of drift, capping the tertiary strata of the southern coast of Hampshire and the opposite eastern side of the Isle of Wight. Flint tools, exactly resembling those of Abbeville and St. Acheul have here been found in situations which show that not only certain valleys on the Hampshire coast, but even the channel of the Solent must have been scooped out since man inhabited the district. Remains of human art, in the shape of implements made of stone, bone, and horn, together with mammoth tusks, on which rude carvings exist, were found by Messrs. Lartet, Christy, and others, in the caverns of Dordogne in central France, which have been decided to belong to a more modern period than the flint implements of the drift. At this epoch the reindeer abounded in the S. of

France, implying that a great change of climate has since taken place, although the general outlines of the surface of the country have undergone no alteration.

We have no measure for such remote periods of time; no certain date can be assigned for man's creation; but chronologists have long come to the conclusion that it must have been vastly anterior to the historical period. From the age of Galileo to the present day, the world has been startled from time to time by the results of science; but we may rest assured that they never can be inconsistent with the Scriptures, though they frequently have been with our interpretation of them.

CHAPTER II.

GENERAL VIEW OF THE CONTINENTS.

§ 1. Direction of the forces that raised the continents. § 2. Proportion of land and water; size of the continents and islands; outline of the land. § 3. Extent of coasts, and proportion they bear to the areas of the continents. § 4. Elevation of the continents. § 5. Forms of mountains; direction of the chains of mountains. § 6. Connection between physical geography of countries and their geological structure; analogies of the form and contour of countries. § 7. Interruptions in continents and mountain-chains; table-lands and plains.

§ 1. AT the end of the tertiary period the earth was much in the same state as it is at present with regard to the distribution of land and water. The preponderance of land in the northern hemisphere indicates a prodigious accumulation of internal energy under these latitudes at a very remote geological period. The forces that raised the two great continents above the deep, when viewed on a wide scale, must evidently have acted at right angles to one another, nearly parallel to the equator in the old continent, and in the direction of the meridian in the new; yet the structure of the opposite coasts of the Atlantic points at some connexion between the two.

The mountains, from their rude and shattered condition, bear testimony to repeated violent convulsions similar to modern earthquakes; while the high table-lands, and that succession of terraces by which the continents sink down from their mountain ranges to the plains, to the ocean, and even below it, indicate also that the land must have been heaved up occasionally by slow and gentle pressure, such as appears now to be gradually elevating the coast of Scandinavia and other parts of the earth. The periods in which these majestic operations were effected must have been incalculable, since the dry land occupies an area of nearly 38,000,000 of square miles.

§ 2. The ocean covers nearly three-fourths of the surface of the globe, but its distribution is very unequal, whether it be considered with regard to the northern and southern hemispheres, or the eastern and western. Independently of Victoria Land in the Arctic regions, whose extent is unknown, the quantity of land in the northern hemisphere is three times greater than in the southern. In the latter it occupies only one-sixteenth of the space between the Antarctic Circle and the 13th parallel of south latitude, while between the corresponding parallels in the northern hemisphere the extent of land and water is nearly equal. If the globe be divided into two hemispheres, so that the centre of one shall be a point midway between Pembroke and Wexford, in St. George's Channel, it will be found that one hemisphere contains as much land as water, while in the other the sea exceeds the land in the proportion of nearly 8 to 1. In consequence of this very unequal arrangement of the solid and liquid portions of the surface of the earth, England is nearly in the centre of the greatest mass of land, and its antipodes, the islands of New Zealand, are in the centre of the greatest mass of water. In fact, only one thirteenth of the land has land directly opposite to it in the opposite hemisphere, and under the equator five-sixths of the circumference of the globe is water. It must however be observed that there is still an unexplored region within the Antartic circle more than twice the size of Europe; and although there is reason to believe that the North Polar basin is an open sea, it has not been navigated. With regard to the land alone, the old continent has an area of about 24,000,000 square miles, while the extent of America is 11,000,000, and that of Australia with its islands scarcely 3,000,000. Africa is more than three times the size of Europe, and Asia is more than four times as large. The extent of the continents is 23 times greater than that of all the islands taken together.

The north polar lands are now well known to a high latitude. Greenland, the domain of perpetual snow, is probably an immense island; and the discovery, by Ross, of an extensive mass of high volcanic land near the south pole is an important event in the history of physical science, though the stern severity of the climate must for ever render it unfit for the abode of animated beings, or even for the support of vegetable life. It seems to form a counterpoise to the preponderance of dry land in the northern hemisphere. There is something sublime in the contemplation of these lofty and unapproachable regions—the awful realm of ever-during ice and perpetual fire, whose year consists of one day and one night. The strange and terrible symmetry in the nature of the lands within the polar circles, whose limits are to us a blank, where the antagonist principles of cold and heat meet in their utmost intensity, fills the mind with that awe which arises from the idea of the unknown and the indefinite.

The tendency of the land to assume a peninsular form is very remarkable, and it is still more so that almost all the peninsulas trend to the south—circumstances that depend on some unknown cause which seems to have acted very extensively. The continents of South America, Africa, and Greenland are peninsulas on a gigantic scale, all directed to the south; the peninsula of India, the Indo-Chinese peninsula, those of Korea, Kamtchatka, Florida, California, and Aliaska, in North America, as well as the European peninsulas of Norway and Sweden, Spain and Portugal, Italy and Greece, observe the same direction. All the latter have a rounded form except Italy, whereas most of the others terminate sharply, especially the continents of South America and Africa, India and Greenland, which have the pointed form of wedges; while some are long and narrow, as California, Aliaska, and Malacca. Many of the peninsulas have an island or group of islands at their extremity; as South America, which is terminated by the group of Tierra del Fuego; India has Ceylon; Malacca has Sumatra and Banca; the southern extremity of Australia ends in Tasmania or Van Diemen's Land: a chain of islands runs from the end of the peninsula of Aliaska; Greenland has a group of islands at its extremity; and Sicily lies close to the southern termination of Italy. It has been observed, as another peculiarity in the structure of peninsulas, that they generally terminate boldly, in bluffs, promontories, or mountains, which are often the last portions of the continental chains. South America terminates in Cape Horn, a high promontory, which is the visible termination of the Andes; Africa with the Cape of Good Hope; India with Cape Comorin, the last of the Ghauts; Australia ends with the South-East Cape in Tasmania; and Greenland's extreme southern point is the elevated bluff of Cape Farewell.[1]

There is a strong analogy between South America and Africa in form and the unbroken mass which their surface presents, while North America resembles Europe in being much indented by inland seas, gulfs, and bays. Eastern Asia is evidently continued in a subaqueous continent from the Indian Ocean across the Pacific nearly to the west coast of America, of which Australia, the Indian Archipelago, the islands of the Asiatic coast and of Oceania, are the great table-lands and summits of its mountain-chains. With the exception of a vast peninsula in Siberia between the mouths of the rivers Yenissei and Khatanga, and the unknown regions of Greenland, the two great continents terminate in a very broken line to the north; and as they sink beneath the Icy Ocean, the tops of their high lands and mountains rise above the waves, and stud the coast with innumerable snow-clad rocks and islands. The 70th parallel is the average latitude of these northern shores, which have a great similarity on each side of Behring Strait in form, direction, and in the adjacent islands.

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[1] This very general view of the structure of the globe originated chiefly with the celebrated German geologist Von Buch, and has been much extended and developed by M. Elie de Beaumont, one of the most eminent of modern geologists.

§ 3. The peninsular form of the continents adds greatly to the extent of their coasts, of such importance to civilization and commerce. All the shores of Europe are deeply indented and penetrated by the Atlantic Ocean, which has formed a number of inland seas of great magnitude, so that it has a greater line of maritime coast, compared with its size, than any other quarter of the world. The extent of coast from the Strait of Waigatz, in the Polar Ocean, to the Strait of Yenikalé, at the entrance of the Sea of Azof, is about 17,000 miles. The coast of Asia has been much worn by currents, and possibly also by the action of the ocean occasioned by the rotation of the earth from W. to E. On the S. and E. especially it is indented by large seas, bays, and gulfs; and the eastern shores are rugged and encompassed by chains of islands which render navigation dangerous. Its maritime coast is about 33,000 miles in extent.

The coast of Africa, 16,000 miles long, is very little broken, except, perhaps, at the Gulf of Guinea and in the Mediterranean. The shores of North America have probably been much altered by the equatorial current and the Gulf-stream. It is probable that these currents, combined with volcanic action, have hollowed out the Gulf of Mexico, and separated the Antilles and Bahama Islands from the continent. The W. coast of North America is less broken, but on the Icy Ocean it consists of a labyrinth of gulfs, bays, and creeks. The shores of South America on both sides are very entire, except towards Southern Chile and Cape Horn, where the tremendous surge and currents of the Ocean in those high latitudes have eaten into the land, and produced endless sounds and fiords which run far into the interior. The whole continent of America has a sea-coast of 31,000 miles in extent. Thus it appears that the ratio of the number of linear miles in the coast-line to the number of square miles in the extent of surface, in each of these great portions of the globe, is 164 for Europe, 376 for Asia, 530 for Africa, and 359 for America. Hence the proportion is most favourable to Europe, with regard to civilization and commerce; America comes next, then Asia, and last of all Africa, which has every natural obstacle to contend with, from the extent and nature of its coasts, the desert character of much of the interior of the continent, and the insalubrity of its climate, on the Atlantic coast at least.

§ 4. The continents had been raised from the deep by a powerful effort of the internal forces acting under widely extended regions; and the stratified crust of the earth either remained level, rose in undulations, or sank into cavities, according to its intensity. Some thinner portions of the earth's surface, giving way to the internal forces, had been rent into deep fissures; and the mountain masses had been raised by violent concussions, perceptible in the convulsed state of their strata. The centres of maximum energy are marked by the plutonic rocks,[1] which generally form the nucleus or axis of the mountain masses, on whose flanks the stratified rocks are tilted at all angles to the horizon, whence, declining on every side, they sink to various depths, or stretch to various distances in the plains. Enormous as the mountain-chains and table-lands are, and prodigious as the forces that elevated them, they bear a very small proportion to the mass of the level continents and to the vast power which raised them even to their inferior altitude. Both the high and the low lands have been elevated at successive periods; some of the very highest mountain-chains are of but recent geological date; and some chains that are now far inland once stood up as islands above the ocean, while marine strata filled their cavities and formed round their bases.

§ 5. Notwithstanding the various circumstances of their elevation, there is everywhere a certain regularity of form in mountain masses, however unsymmetrical they may appear at first sight; and rocks of the same kind have identical characters in every quarter of the globe. Plants and animals vary with climate, but a granite mountain has the same peculiarities in the southern as in the northern hemisphere, at the equator as near the poles. Insulated mountains are rare, and are generally of volcanic origin. Mountains generally appear in groups intersected by valleys in every direction, and more frequently in extensive chains symmetrically arranged in a series of parallel ridges, separated by narrow longitudinal valleys, the highest and most rugged of which occupy the centre; when the chain is broad, and of the first order in point of magnitude, peak after peak rises in endless succession. The lateral ridges and valleys are constantly of less elevation, and are less bold in proportion to their distance from the central mass, till at last the most remote ridges sink down into gentle undulations. Extensive and lofty branches diverge from the principal chains at various angles, and stretch far into the plains. They are often as high as the chains from which they spring, and it happens not unfrequently that these branches are united by transverse ridges, so that the country is often widely covered by a network of mountains; and at the point where these offsets diverge there is frequently a knot of mountains spreading over hundreds of square miles.

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[1] Plutonic rocks are granite and others which owe their origin to fire or igneous action.

One side of a mountain range is usually more precipitous than the other, but there is nothing in which the imagination misleads the judgment more than in estimating the steepness of a declivity. In the whole range of the Alps there is not a single rock which has 1600 feet of perpendicular height, or a vertical slope of 90°. The declivity of Mont Blanc towards the Allée Blanche, precipitous as it appears to be, does not amount to 45°; and the mean inclination of the Peak of Teneriffe, according to Humboldt, is only 12° 30′. The Silla of Caraccas, which rises precipitously from the Caribbean Sea, at an angle of 53° 28′, to the height of between 6000 and 7000 feet, is a majestic instance of, perhaps, the nearest approach to verticality of any great height yet known.

The circumstances of elevation are not the only causes of that variety observed in the summits of mountains. A difference in the composition and internal structure of a rock has a great influence upon its general form, and on the degree and manner in which it is worn by the weather. Thus dolomite assumes generally the form of high, abrupt, and insulated peaks; crystalline schists and gneiss assume the form of needles, as in the Alps; slates and quartziferous schists take the form of triangular pyramids; calcareous rocks a rounded form, or that of table-lands with abrupt declivities; serpentine and trachyte are often of a dome form; phonolites assume a pyramidal one; dark walls, like those in Greenland, and of some of our Western Islands of Scotland, are of trap and basalt; and volcanoes are indicated by blunt cones and craters. Thus the mountain-peaks often indicate by their form their geological structure.

§ 6. Viewing things on a broad scale, it appears that there is also a very striking connexion between the physical geography or external aspect of different countries and their geological structure. By a minute comparison of the different parts of the land, M. Boué has shown that similarity of outward forms, while indicating similarity in the producing causes, must also to a large extent indicate identity of structure; and therefore, from the external appearance of an unexplored country, its geological nature may be inferred, at least to a certain extent. This he illustrates by pointing out a correspondence, even in their most minute details, between the leading features of Asia and Europe, and the identity of their geological structure. It has been justly observed that, when the windings of our continents and seas are narrowly examined, and the more essential peculiarities of their contours contemplated, it is evident that Nature has not wrought after an indefinite number of types or models, but that, on the contrary, her fundamental types are very few, and derived from the action of definite constructive forces on a primary base.[1] The whole of our land and sea, in fact, may be decomposed into a less or greater number of masses, either exhibiting all these fundamental forms or merely a portion of them. The peninsular structure of the continents, with their accompanying islands, is a striking illustration of the truth of this remark, and many more might be adduced. It follows, as a consequence of that law in Nature's operations, that analogy of form and contour throws the greatest light on the constitution of countries far removed from each other. Even the picturesque descriptions of a traveller often afford information of which he may be little aware.

§ 7. Continents and mountain-chains are often interrupted by posterior geological changes, such as clefts and cavities formed by erosion, as evidently appears from the correspondence of the strata. The chalk cliffs on the opposite sides of the British Channel show that Britain was at one time united to the continent; the formation of the Orkneys and of the N. of Ireland are the same with that of the Highlands of Scotland; so are those on each side of the Strait of Gibraltar: that of Turkey in Europe passes into Asia Minor, the Crimea into the Caucasus; a volcanic region bounds the Strait of Babelmandeb on both sides, and Behring Strait divides the strata of a similar age in the two great continents. Such is also particularly the case with coast islands.

Immediately connected with the mountains are the high table-lands which form so conspicuous a feature in the Asiatic and American continents. These perpetual storehouses of the waters send their streams to refresh the plains, and to afford a highway between nations. Table-lands of less elevation, sinking in terraces of lower and lower level, constitute the links between the high ground and the low, the mountains and the plains, and thus maintain the continuity of the land. They frequently are of the richest soil, and enjoy the most genial climate, affording a delightful and picturesque abode to man, though the plains are his principal dwelling. Sloping imperceptibly from the base of the inferior table-lands, or from the last undulations of the mountains, to the ocean, the plains carry off the superfluous waters. Fruitfulness and sterility vary their aspect: immense tracts of the richest soil are favoured by climate and hardly require culture; a greater portion is only rendered productive by hard labour, compelling man to fulfil his destiny; while vast regions are doomed to perpetual barrenness, never gladdened by a shower.

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[1] M. Boué.

CHAPTER III.

HIGH LANDS OF THE GREAT CONTINENT.

§ 1. Form of the Great Continent. § 2. The Atlas, Spanish, French, and German mountains. § 3. The Alps, Balkan, and Apennines. § 4. Glaciers. § 5. Geological notice.

§ 1. THE form of the great continent has been determined by an immense zone of mountains and table-land, lying between the 30th and 40th or 45th parallels of north latitude, which stretches across it from W.S.W. to E.N.E. from the coasts of Barbary and Portugal, on the Atlantic Ocean, to the farthest extremity of Asia, at Behring Strait, in the North Pacific. North of this lies a vast plain, extending almost from the Pyrenees to the extremity of Asia, the greater portion of which is a dead level, or having low undulations, uninterrupted except by the Scandinavian and British system on the N., and the Ural chain, which is of inconsiderable elevation. The low lands S. of the mountainous zone are much indented by the ocean, and of the most diversified aspect. A great part of the flat country lying between the China Sea and the River Indus is of exuberant fertility, while that between the Persian Gulf and the foot of the Atlas is, with some happy exceptions, one of the most desolate tracts on the earth. The southern lowlands, too, are broken by a few mountain systems of considerable extent and height.

§ 2. The Atlas and Spanish mountains form the western extremity of that great zone of high land that girds the old continent almost throughout its extent: these two mountain systems were at one time united, and from their geological structure, and also the parallelism of their chains, they must have been elevated by forces acting in the same direction; the Strait of Gibraltar, a sea-filled chasm nearly 500 fathoms deep, now divides them.[1]

A very elevated and continuous mountain region extends in a broad belt along the N.W. of Africa, from the promontory of

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[1] By the soundings of the late M. Vicendon Dumoulin, an eminent French hydrographical engineer and surveyor, the greatest depth in the Straits does not reach 500 fathoms, although until lately it had been considered nearly double that quantity.

Gher, on the Atlantic, to the Gulf of Sidra, on the Mediterranean, embracing all the high land of Morocco, Algiers, and Tunis. It is bounded by the Atlantic and Mediterranean, and insulated from the rest of Africa by the desert of Sahara.

This mountain system consists of three parts. The chain of the Greater Atlas, which is farthest inland, extends from Cape Gher, on the Atlantic, to the Lesser Syrtis; and, in Morocco, forms a group of mountains 15,000 feet high, covered with perpetual snow.

The Lesser Atlas begins at Cape Spartel (the ancient Cape Cotes) opposite to Gibraltar, and runs parallel to the coast of the Mediterranean till it reaches the Gharian range in Tripoli, the last and lowest of the Little Atlas, which runs in an easterly direction, diminishing gradually in height till it is lost in the plain of the Great Syrtis. That long, rugged, but lower chain of parallel ridges and groups which forms the bold coasts of the Strait of Gibraltar and the Mediterranean, is only a portion of the Lesser Atlas, which, covered with snow, rises above it majestically. The flanks of the mountains are generally clothed with forests, but their summit is one uninterrupted line of bare inacessible rocks, and they are rent by fissures frequently not more than a few feet wide—a peculiar feature of the whole system.

The Middle Atlas, lying between the two great chains, consists of a table-land, rich in valleys and rivers, which rises in successive terraces to the foot of the Greater Atlas, separated by ridges of hills parallel to it. This wide and extensive region has a delightful climate, abounds in magnificent forests, and valleys full of vitality. The Greater Atlas is calcareous in its central portion, and composed of granite and schistose rocks near the sea-coast.

The Spanish peninsula consists chiefly of a table-land traversed by parallel ranges of mountains, and is surrounded by the sea, except where it is separated from France by the Pyrenees, which extend from the Mediterranean to the Bay of Biscay, and are continued by the Cantabrian chain to Cape Finisterre on the Atlantic.

The Pyrenean chain is of moderate height at its extremities, but its summit maintains a waving line whose mean altitude is 8000 feet; it rises to a greater height on the E.; its highest point is the Maladetta or Nethou, 11,170 feet above the sea. The snow lies deep on these mountains during the greater part of the year, and is perpetual on the highest parts; but the glaciers, which are chiefly on the northern side, are neither so numerous nor so extensive as those of the Alps.

The greatest breadth of this range is about 60 miles, and its length 270. It is so steep on the French side, so rugged, and so notched, that from the plains below its summits look like the teeth of a saw, whence the term Sierra has been appropriated to mountains of this form. On the Spanish side, gigantic sloping spurs or offsets, separated by deep valleys, extend to the banks of the Ebro.

The interior of Spain is a table-land with an area of 93,000 square miles, nearly equal to half of the peninsula. It dips to the Atlantic from its western side, where its altitude is about 2300 feet. There it is bounded by the Iberian mountains, which begin at the point where the Pyrenees take the name of the Cantabrian chain, and run in a tortuous south-easterly direction through all the kingdom, constituting the eastern boundary of Castile and Murcia, and sending many branches through those provinces to the Mediterranean: its most elevated portion is the Sierra de Moncayo between Calatayud and Tarazona, W. of Saragossa.

The Cantabrian chain attains its greatest height in the Montes de Europa, 8500 feet, where it is composed of rugged peaks of carboniferous limestone.

Four nearly parallel ranges of mountains originate in this limiting chain, running from E.N.E. to W.S.W. diagonally across the peninsula to the Atlantic. Of these the high chain of the Guadarrama and the Sierra de Toledo cross the table-land; the W. continuation of the former, the Sierra de los Gredos, contains the Peak of Almanzor, after the Màladetta, and the Sierra Nevada of Grenada, the highest in Spain; the Sierra Morena, so called from the dark colour of its forests on the southern edge; and lastly, the Sierra Nevada, which though only 100 miles long and 50 broad, is the finest range of mountains in Europe after the Alps and Pyrenees, and traverses the plains of Andalusia and Grenada. The table-land is monotonous and bare of trees; the plains of Old Castile are as naked as the Steppes of Siberia; the eastern part is composed of a bare diluvial soil, and uncultivated, except in the valleys of denudation and along the banks of the rivers. Corn and wine are produced in abundance on the widely-extended plains of New Castile and Estremadura: other places serve for pasture. The table-land becomes more fertile as it approaches towards Portugal, which is altogether more productive than Spain, though the maritime provinces of the latter on the Mediterranean are beautifully luxuriant, with a semi-tropical vegetation.

Granite and paleozoic rocks prevail chiefly in the Spanish mountains, and give them their peculiar, bold, serrated aspect; whilst secondary and even tertiary rocks abound in the less elevated ranges, often rising to a very considerable elevation. Some of the valleys and extensive table-lands between the parallel ranges, through which the great Spanish rivers flow to the Atlantic, appear to have been at one time the basins of lakes.[1]

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[1] The physical geography and geology of Spain have received great ad-

The mass of high land is continued through the S. of France, at a much lower elevation, by chains of hills and table-lands, the most remarkable of which are the Montagnes Noires, and the great plateau of Auvergne, once the theatre of violent volcanic action, which continued from the beginning to the middle of the tertiary period, presenting very perfect cones and craters: some of the highest, as the Puy de Dôme, are trachytic domes. The trachytic group of Mont Doré, the highest peak of which, the Puy de Sancy, rises to the height of 6188 feet, includes an immense crater of elevation.[1] The volcanic mountains of Auvergne, and the Cévennes, which are less elevated, are the most remarkable of the French system; the eastern offsets from the latter reach the right bank of the Rhone in the group of the Vivarais. In fact, these French mountains are the link between the more elevated masses of Western and Eastern Europe.

The eastern and highest part of the European portion of the mountain-zone begins to rise above the low lands about the 52nd parallel of N. latitude, ascending by terraces, groups, and chains of mountains, through six or seven degrees of latitude, till it reaches its highest point in the great range of the Alps and Balkan. The descent on the S. side of this lofty mass is much more rapid and abrupt, and the immediate offsets from the Alps shorter; but, taking a very general view, the Apennines and mountains of Northern Sicily, those of Greece and the southern part of Turkey in Europe, with those of all the islands of the adjacent coasts, are but outlying members of the general protuberance.

The chains of the Hyrcanian mountains, the Sudetes, and the Carpathian mountains, form the northern boundary of these high lands; the first, consisting of 3 parallel ridges, extends from the right bank of the Rhine to the centre of Germany, about 51° or 52° of N. lat., with a mean breadth of about 100 miles, and terminates in the knot of the Fichtelgebirge, on the confines of Bavaria and Bohemia, covering an area of 9000 square miles. The Sudetes begin on the E. of this group, and, after a circuit of 300 miles round Bohemia, terminate at the small elevated plain of the upper Oder,

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ditions of late years from the researches of one of the most eminent of European geologists, M. E. de Verneuil, who has determined barometrically the elevation of many of the most remarkable points, at the same time that he has illustrated the geology of nearly the whole Peninsula in a most masterly manner.

[1] A *crater of elevation* is a mountain, generally of a conical shape, whose top has sunk into a crater or hollow, after the internal force which raised it was withdrawn, but from which no lava had issued. Dome-shaped mountains owe their form to internal pressure, probably from lava, but which have not again sunk into a cavity or crater.

which connects them with the Carpathian mountains. No part of these limiting ranges attains the height of 5000 feet, except the Carpathians, some of which are very high. The latter consist of mountain-groups united by elevated plains. The highest point is in the S.E. of Transylvania, before it reaches the Danube, which separates it from the secondary branch of the Balkan, where Mount Butschetje rises to 9528 feet. The Lomnitzer Spitze in the Tatra group is 8729 feet. The chief pass across these mountains is the Rothenthurm Pass in the valley of the Aluta. Spurs decline in undulations from these limiting chains towards the great northern plain, and the country to the S., intervening between them and the Alps, is covered with an intricate network of elevations and plains of moderate height.

§ 3. The higher Alps, which form the western crest of the elevated zone, may be said to commence from Cape delle Melle in the Gulf of Genoa, and bend round by the W. and N. to Mont Blanc; then turning E.N.E. they run through the Grisons and Tyrol to the Great Glockner, in 40° 7′ N. lat. and 12° 43′ E. long., where the higher Alps terminate after a course of 420 miles. Throughout its whole extent this chain is lofty; many of its peaks rise above the line of perpetual snow; the most elevated part is situated between the Col de la Seigne, on the western shoulder of Mont Blanc, and the Simplon. The highest mountains in Europe are comprised within this space, not more than 60 miles long, where Mont Blanc, the highest of all, has an absolute elevation of 15,744 feet. The central ridge of the higher Alps is jagged with peaks, pyramids, and needles of bare and almost perpendicular rock, rising from fields of perpetual snow and rivers of ice to an elevation of 14,000 feet. Many parallel chains and groups, alike rugged and snowy, press on the principal crest, and send their flanks far into the lower grounds. Innumerable secondary branches, hardly lower than the main crest, diverge from it in various directions: of these the chain of the Bernese Alps is the highest and most extensive. It branches off at the St. Gothard from the principal chain, and, running nearly parallel to it, separates the Valais from the Canton of Berne, and with its ramifications forms one of the most remarkable groups of mountain scenery in Europe. Its endless maze of sharp ridges and bare peaks, mixed with gigantic masses of pure snow, fading coldly serene into the blue horizon, presents a scene of sublime quiet and repose, unbroken but by the avalanche or the thunder.

At the Great Glockner the chain of the Alps divides into two branches, forming the Noric and Carnic Alps: the former running towards Vienna, the latter forming the continuation of the principal stem. Never rising to the height of perpetual snow, it separates the Tyrol and Upper Carinthia from Venetia, and, taking the name of the Julian Alps at Mont Terglou, it runs S.E., under various names, till it joins the Eastern Alps, or Balkan, under the 18th meridian. Offsets from this chain cover all the neighbouring countries.

It is difficult to estimate the breadth of the Alpine chain: that of the higher Alps is about 100 miles; it increases to 150 E. of the Grisons, and to 200 between the 15th and 16th meridians, but is not more than 80 at its junction with the Balkan.

The Stelvio, 9177 feet above the sea, is the highest carriage-pass in these mountains. Those of the Mount Cenis (6772), St. Gothard (6808), Simplon (6592), Splugen (6940), and Ampezzo, go directly over the crest of the Alps. Passes very rarely go over the summit of a mountain; they generally cross a depression between higher peaks, ascending by the valley of a torrent, and descending by a similar depression on the other side.

The frequent occurrence of extensive deep lakes is a peculiar feature in European mountains, rarely to be met with in the Asiatic system, except in the Altaï and on the elevated plains.

With the exception of the Jura, whose pastoral region is about 3000 feet above the sea, there are no elevated table-lands in the Alps or European mountains; the tabular form, so eminently characteristic of the Asiatic high lands, begins in the Balkan. The Oriental peninsula rises by degrees from the Danube to Bosnia and Upper Macedonia, which are some hundred feet above the sea: and the Balkan extends 600 miles along this elevated mass, from the continuation of the Dinaric and Julian Alps to Cape Emineh on the Black Sea. It begins by a table-land 70 miles long, traversed by low hills ending, towards Albania and Myritida, in precipitous limestone peaks from 6000 to 7000 feet high. Rugged mountains, all but impassable, succeed to this, in which the domes and needles of the Schandach, or ancient Scamus, are covered with snow till June. Another table-land follows, whose marshy surface is bounded by mural precipices at Mount Arbelus, near the town of Sophia. There the Hæmus, or Balkan properly so called, commences, and runs in parallel ridges separated by longitudinal valleys to the Black Sea, dividing the plains between the Lower Danube and the Propontis into nearly equal parts. There are few passes in the central ridge, and where there is no lateral ridge the precipices descend at once to the plains.

The Balkan is rent by terrific fissures cutting through the chains and table-lands, so deep and narrow that daylight is almost excluded. These chasms afford the safest passes for beasts of burthen. There is but one high road across the chain, called Trajan's Gate.

The Mediterranean is the southern boundary of the elevated zone of Eastern Europe, whose last offsets rise in rocky islands along the coasts. The mountains of Sardinia and Corsica may be considered as outlying members of the Maritime Alps, while shorter offsets end in the plains of Lombardy, enclosing the magnificent scenery of the Italian lakes. Even the Apennines, whose chain has given its form to the peninsula of Italy, are but secondary on a greater scale to the broad central band, as well as the mountains and high land in the north of Sicily, which form the continuation of the Calabrian range.

The Apennines, beginning where the Maritime Alps terminate, enclose the Gulf of Genoa, and run through the centre of Italy to the middle of Calabria, where they split into two branches, one of which continues to Capo di Leuca, on the Gulf of Taranto, the other to Cape Spartivento, near the Strait of Messina. The whole length is about 800 miles. None of the Apennines rise above the line of perpetual snow, though snow lies during nine months of the year on the Monte Corno in the Gran Sasso d'Italia (9521 feet high), in Abruzzo Ulteriore.

Offsets from the Julian and Eastern Alps render Dalmatia and Albania, perhaps, the most rugged tract in Europe; and the Pindus, which forms the watershed of Greece, diverges from the latter chain, and, running south 200 miles, separates Albania from Macedonia and Thessaly.

Greece is a country of mountains, and, although none are perpetually covered with snow, it lies during a great part of the year on several of their summits. The highest point is Mount Guiona in Doris, 8239 feet. The chains terminate in boldly projecting headlands, which reach far into the sea, and reappear in the numerous islands and rocks which stud that deeply indented coast. The Grecian mountains, like the Balkan, are much torn by transverse fractures. The defile of Blatamana and the Gulf of Salonica are examples. The Adriatic, the Dardanelles, and the Sea of Marmora limit the secondary ranges that branch from the southern part of the Balkan.

The valleys of the Alps are deep, long, and narrow; those among the mountains of Turkey in Europe and Greece are mostly caldron-shaped hollows, often enclosed by mural rocks. Many of these cavities of great size lie along the foot of the Balkan. In the Morea they are so encompassed by mountains that the water has no escape but through the porous soil, consisting of tertiary strata, some of which have formed the bottom of lakes. Caldron-shaped valleys occur also in most volcanic countries, as Italy, Sicily, and central France.

The table-lands which constitute the tops of mountains or of mountain chains are of a different character from those terraces by which the high lands slope down to the low. The former are on a small scale in Europe, and of forbidding aspect, with the exception of the Jura, which is pastoral, whereas the latter are almost always habitable and cultivated. The mass of high land in south-eastern Europe shelves on the north to the great plain of Bavaria, 3000 feet high; Bohemia, which slopes from 1500 to 900 feet; and Hungary, from 4000 to 300 above the sea. The descent on the south side of the Alps is considerably the most rapid, the distance of the plains from the centre of the chain being shorter.

§ 4. It is scarcely possible to estimate the quantity of ice on the Alps: it is said, however, that, independent of the glaciers in the Grisons, there are 1400 square miles of glacier in the Alpine range, from 80 to 600 feet thick. There are no glaciers east of the Great Glockner, except in the small group of Hallstadt. Thirty-four bound the snowy regions of Mont Blanc, covering an area of 1819 miles, whilst it is estimated that 95 square miles of snow and ice clothe that giant of the chain. Some glaciers have been permanent and stationary in the Alps from time immemorial, while others now occupy ground formerly cultivated or covered with trees, which the irresistible force of the ice has swept away. These ice-rivers, formed on the snow-clad summits of the mountains, fill the hollows and high valleys, hang on the declivities, or descend by their gravity through the transverse valleys to the plains, where they are cut short by the increased temperature, and deposit the rocks and rubbish which had fallen upon them from the heights above, forming those accumulations called *moraines*; but their motion is so slow in some instances that generations may pass before a stone fallen on the upper end of a long glacier can reach the terminal moraine. In the Alps the annual rate of motion of the glaciers varies extremely, according to the state of the glacier itself, and of its slope. Rates of motion varying from 14 feet to 600 feet annually have been observed. As in rivers, the motion is most rapid in the centre, and slower along the sides and bottom on account of friction. It is slower in winter, although it does not cease, because the winter's cold penetrates the ice, as it does the soil, only to a limited depth. Glaciers are not of solid ice; they consist of a mixture of ice, snow, and water, so that they are in some degree flexible and viscous, acquiring more solidity as they descend to lower levels. Although evaporation goes on at their surface, they are not consumed by it. The terminal front is perpetually melting; it is steep and inaccessible, owing to the configuration of the ground over which it tumbles in its icy cascade, sometimes several hundred feet high. The glacier in its middle course is rather level, the higher part very steep, and the surface is convex and uneven, and rent by crevices into which the purest blue streams fall in rushing cascades while the sun is above the horizon; but they freeze at his setting, and then a death-like silence prevails. The masses of rock and large stones that fall on them from the surrounding heights protect the ice below from the sun which melts it all round, so that at last they rest on elevated pinnacles till they fall off by their weight, and in this manner some of those numerous pyramids are formed with which the surface is bristled. Small stones, on the contrary, absorb the sun's heat, and melt the ice under them into holes in which they sink, forming so many small wells. Throughout much of the length of a glacier the winter's snow melts from its surface as completely as it does from the ground; it is fed from above, for in the upper part the snow never melts, but accumulates in a stratified form, and is consolidated. In some of the largest glaciers, where there is a difference in level of some thousands of feet between the origin and termination, the pressure is enormous, and so irresistible as to carry all before it; even the thickest forests are at times overwhelmed and crushed by them.

Glaciers advance or retire according to the severity or mildness of the season: they have been advancing in Switzerland of late years, but they are subject to cycles of unknown duration. From the moraines, as well as the striæ scratched on the rocks over which they have passed, M. Agassiz considers that the valley of Chamouni was at one time occupied by a glacier that had moved towards the Col de Balme. A moraine 2000 feet above the Rhone at St. Maurice would appear to indicate that, at a remote period, glaciers had covered Switzerland to the height of 2155 feet above the level of the lake of Geneva.

Their increase is now limited by various circumstances—by evaporation at their surface, by blasts of hot air which occur at all heights, but chiefly by the mean temperature of the earth, which, being always above the freezing-point in those latitudes, melts the under surface of the glacier, giving rise to a perpetual current, which, united to the natural springs that rise under the frozen mass, and to the rain and melted snow that penetrate through the crevices, forms a stream of turbid water which works out an icy cavern at the extremity of the glacier, and flows from it into the lower ground. Thus a glacier "begins in the clouds, is formed by the mountains, and ends in the ocean."[1]

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[1] The reader who may wish for a more detailed view on this subject is referred to the writings of Professor Agassiz, and to Professor James Forbes' volumes on Glaciers, a work which is a model of exact observation, combined with such accurate physical and mechanical deductions as could only be arrived at by one eminently conversant with the highest principles of physics and mathematical investigations; and to the later researches of Professor Tyndall, which have modified, on some secondary points, Professor Forbes' views and discoveries.

§ 5. The crystalline and upper Palæozoic formations are enormously developed in northern Europe; the secondary and tertiary are not less so in the central part of the continent; and although the latter continue to be the prevailing strata in the S., they are so much mixed with crystalline rocks that the geology becomes very complicated. Norway, Sweden, Lapland, and Finland, are for the most part crystalline, while the rest of northern Russia belongs to the upper Palæozoic period. Siberia, and a long tract S. of it, are formed of secondary strata. The whole of southern Russia, to the shores of the Black Sea and Caspian, belongs to the secondary and tertiary periods; while tertiary rocks prevail throughout Germany, Denmark, and Holland, to the shores of the North Sea. Metamorphic slates are highly developed in Southern and Eastern Europe, and form some of the most elevated pinnacles of the Alpine crest and its offsets, of the Caucasus and principal chains in Greece and Turkey in Europe; but the secondary fossiliferous strata constitute the chief mass and often rise to the highest summits; indeed, secondary limestones occupy a great portion of the high land of Eastern Europe. Calcareous rocks form two great mountain zones on each side of the central chain of the Alps, and rise occasionally to altitudes of 10,000 or 12,000 feet. They constitute a great portion of the central range of the Apennines, and fill the greater part of Sicily. They are extensively developed in Turkey in Europe, where the plateau of Bosnia, with its high lands on the S., part of Macedonia, and Albania with its islands, are principally composed of them.[1] Tertiary strata of great thickness rest on the flanks of the Alps, and rise in some places to a height of 5000 feet; zones of the Pliocene period flank the Apennines on each side, filled with organic remains, and half of Sicily is covered with tertiary strata. With the exception of the islands in the Baltic, and a district S. of the Gulf of Finland, which is Palæozoic, that formation often mixed with granite prevails near or along the shores of the Atlantic, but not continuously. A district at North Cape is Palæozoic; the Lofoden Isles are of granite; it again appears in small patches in the Norwegian mountains, which are Palæozoic. The whole of Brittany consists of these two formations, the granite being still more abundant, and stretching diagonally across France in patches, even to the shores of the Mediterranean. But in no part of Europe do the rocks under consideration abound so much as on the Atlantic side of the Spanish peninsula: they extend even to the centre of Spain. The Pyrenees are of granite and upper Palæozoic strata, flanked by secondary rocks. Considerable tracts of granite occur in the Moravian, Böhmerwald, and Saxon mountains, but of less importance than those mentioned. It appears that the Atlas, the Sierra Morena, and most of the Spanish mountains, the central chain of the Caucasus, and the Balkan, were raised before the period of the erratic blocks.

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[1] M. Boué.

From numerous dislocations in the strata the Alps appear to have been heaved up by many violent and repeated convulsions, separated by intervals of repose; and different parts of the chain have been raised at different times. For example, the Maritime Alps and the south-western part of the Jura mountains were raised previously to the formation of the chalk; but the tertiary period appears to have been that of the greatest commotions, for nearly two-thirds of the lands of Europe have risen since the beginning of that epoch, and those that existed acquired additional height, whilst some have sunk below their original level. During that period the Alps acquired an additional elevation of between 2000 and 3000 feet; Mont Blanc then attained its present elevation; the Apennines rose 1000 or 2000 feet higher; and the Carpathians seem to have gained an accession of height since the seas were inhabited by the existing species of animals.[1]

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[1] Lyell.

CHAPTER IV.

HIGH LANDS OF THE GREAT CONTINENT—*continued.*

§ 1. Central Asiatic table-land; cradle of the human race. § 2. Western Asiatic table-land. § 3. Caucasian range. § 4. Mountains of Anatolia. § 5. Mountain region of Armenia, Kurdistan, and Azerbijan. § 6. Persian mountains. § 7. Chain of the Hindoo Coosh.

§ 1. THE Dardanelles and the Sea of Marmora form but a small break in the mighty girdle of the old continent, which again appears in immense table-lands, passing through the centre of Asia, of such magnitude that they occupy nearly two-fifths of the continent. Here everything is on a much grander scale than in Europe: the table-lands rise above the mean height of the European mountains, and the mountains themselves that gird and traverse them surpass those of every other country in altitude. The most barren deserts are here to be met with, as well as the most luxuriant productions of animal and vegetable life. The earliest records of the human race are found in this cradle of civilization, and monuments still remain which show the skill and power of those nations that have passed away, but whose moral influence is still visible in their descendants. Customs, manners, and even prejudices carry us back to times beyond the record of history or even of tradition, while the magnitude with which the natural world is here developed evinces the tremendous forces that must have been in action at epochs immeasurably anterior to the existence of man, remote as that appears to be.

The gigantic mass of high land which extends for 6000 miles between the Mediterranean and the Pacific is 2000 miles broad at its eastern extremity, 700 to 1000 in the middle, and somewhat less at its termination. Colossal mountains and elevated terraces form the edges of the lofty plains.

§ 2. Between the 47th and 68th eastern meridians, where the low plains of Hindostan and Bokhara border upon the table-land and reduce its width to 700 or 1000 miles, it is divided into two parts by an enormous group of mountains formed by the meeting of the Hindoo Coosh, the Himalaya, the Kuen-lun, and the transverse ranges of the Bolor Tagh, or Cloudy Mountains: these two parts differ in height, form, and magnitude.

The western portion, which is the table-land of Persia or plateau of Iran, is oblong, extending from the shores of Asia Minor to the Hindoo Coosh and the Solimaun range, which skirts the right side of the valley of the Indus. It occupies an area of 1,700,000 square miles, generally about 4000 feet above the sea, and in some places 7000. The Oriental plateau or table-land, much the largest, has an area of 7,600,000 square miles, its altitude varying from 4000 to 5000 feet at Yarkand, to 17,000 feet in some parts of Tibet.

As the table-lands extend from N.W. to S.E., so also do the principal mountain chains, as well those which bound the high lands as those which traverse them. Remarkable exceptions to this equatorial direction of the Asiatic mass, however, occur in a series of meridional chains, whose axes extend from S.S.E. to N.N.W., between Cape Comorin, opposite to Ceylon, and the Arctic Ocean, under the names of the Western Ghauts, the Solimaun range (which forms the eastern boundary of the table-land of Persia), the Bolor (which is the western limit of the great plateau of Tartary), and the Ural Mountains. These chains, rich in gold, lie in different longitudes, and so alternate among themselves that each begins only in that latitude which has not yet been attained by the preceding one. The Khing-han, in China, also extends from south to north along the eastern slopes of the table-land.[1]

§ 3. The lofty range of the Caucasus, which extends in an unbroken line 700 miles between the Black and Caspian Seas, is an outlying member of the Asiatic high lands. Offsets diverge like ribs from each side of the central crest, which penetrate the Russian Steppes on one hand, and on the other cross the plains of Kara, or valley of the Kur and Rion, and unite the Caucasus to the table-land. The Caucasus presents much magnificent scenery, and the great peaks shoot up from their bases in unbroken walls of rock and ice. The rivers which drain the northern slopes cut their way through gorges in the limestone, which bars their way down to the vast steppes. Fine forests, far surpassing in extent and richness those of the Alps, clothe the sides of the Caucasus, and reach to an elevation variously estimated at 7300 and 7600 feet. There is a total absence of lakes on both sides of the chain, nor are there any great waterfalls. Some parts of these mountains are very high; the Elbruz, on the western border of Georgia, according to the Russian survey, is 18,526 feet. The central portion of the chain, a distance of 120 miles between the peaks of Kasbek (16,546 feet) to the E., and Elbruz to the W., has recently been explored by Mr. Douglas Freshfield and a party, who ascended both of these high peaks, and explored some of the glaciers and all the valleys of the central region. The glaciers of this part of the chain are very extensive, and, though the snow-limit, according to Herr Abich, is 9500 feet, the bases of the great glaciers descend to 7200 feet. The central chain of the Caucasus, according to recent geologists, is chiefly composed of granite; the rocks of both Elbruz and Kasbek are igneous. In addition to these great peaks, the central region contains the elevated summits of Dychtau (16,925 feet) and Koschtantau (17,096 feet) between the two branches of the Tcherek, and several others between 15,000 and 16,000 feet in height. The chief pass across the range is the Krestowaja Gora, commonly called—from a deep gorge in its course—the Dariel Road. Through this valley, which passes under the cliffs of Kasbek, the post-road from Vladikafkaz to Tiflis runs.

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[1] Johnston's Physical Atlas.

§ 4. Anatolia, the most western part of the table-land of Iran, 3000 feet above the sea, is traversed by short chains and broken groups of mountains, separated by fertile valleys, which sink rapidly toward the Archipelago, and end in promontories and islands along the shores of Asia Minor, which is a country abounding in vast, luxuriant, but solitary plains, watered by broad rivers—in Alpine platforms and mountain-ridges broken up by great valleys, opening seawards, with meandering streams. Single mountains of volcanic formation are conspicuous objects on the table-land of Anatolia, which is rich in pasture, though much of the soil is saline and covered with lakes and marshes. A triple range of limestone mountains, 6000 or 7000 feet high, divided by narrow but beautiful valleys, is the limit of the Anatolian table-land along the shores of the Black Sea. Two-thirds of their height are covered with forests, and broken by wooded glens, leaving a narrow coast-line, except near Trebizond, where it is broad and picturesque. The high land is bounded on the south by the serrated snowy range of the Taurus, which, beginning in Rhodes, Cos, and other islands in the Mediterranean, fills the south-western parts of Asia Minor with ramifications; and after following the sinuosities of the iron-bound coast of Karamania in a single lofty range, extends to Samisat, where the Euphrates has cut a passage through this stony girdle.

§ 5. About the 50th meridian the table-land is compressed to nearly half its width; and there the lofty mountainous regions of Armenia, Kurdistan, and Azerbijan tower higher and higher between the Black Sea, the Caspian, and the Gulf of Scanderoon on the Mediterranean. Here the cold treeless plains of Armenia, the earliest abode of man, 7000 feet above the sea, bear no traces of the Garden of Eden; Mount Ararat stands a solitary majestic volcanic cone, 16,916 feet above the sea, shrouded in perpetual snow. Though high and cold, the soil of Armenia is richer than that of Anatolia, and is better cultivated. It shelves on the N.

in luxuriant and beautiful declivities to the low and undulating valley of Kara, S. of the Caucasus; and on the other hand, the broad and lofty belt of the mountains of Kurdistan, rising abruptly in many parallel ranges from the plains of Mesopotamia, form its southern face, and spread their ramifications wide over its surface. They are rent by deep ravines, and in many places are so rugged that communication between the villages is always difficult, and in winter impracticable from the depth of snow. The line of perpetual snow is decided and even along their sides; their flanks are wooded, and the valleys populous and fertile.

A thousand square miles of Kurdistan is occupied by the brackish lake Van, which is seldom frozen, though 566 feet above the sea, and surrounded by lofty mountains.

§ 6. The Persian mountains, of which Elbruz is the principal chain, extend along the northern brink of the plateau, from Armenia, almost parallel to the shores of the Caspian Sea, maintaining a considerable elevation up to the volcanic peak of Demavend, near Tehrân, their culminating point, 21,500 feet above the level of the sea. According to Sir Henry Rawlinson, Mount Judi, overhanging the plain of Assyria, is much higher than Demavend, which, though 90 miles inland, is a landmark to sailors on the Caspian. Elevated offsets of these mountains cover the volcanic table-land of Azerbijan, one of the most fertile provinces of Persia: there the Koh Salavan elevates its volcanic cone. Beautiful plains, pure streams, and peaceful glades, interspersed with villages, lie among the mountains, and the Vale of Khosran Shah, a picture of sylvan beauty, is celebrated as one of the five paradises of Persian poetry. The vegetation at the foot of these mountains on the shores of the Caspian has all the exuberance of a tropical jungle. The Elbruz decreases in height to the E. of Demavend, and then joins the mountains of Khorassan and the Paropamisan range, which appear to be chains of mountains when viewed from the low plains of Khorassan and Balkh, but on the table-land of Persia they merely form a broad hilly country of rich soil, till they join the Hindoo Coosh.

In fact, mountains which bound table-lands have no existence independent of them, being merely their mountainous faces, the highest ranges of which abut on these elevated plains, and rise more or less above them. It is thus that the table-land of Iran is bounded for 1000 miles along the Persian Gulf and Indian Ocean by a mountainous belt of from three to seven parallel ranges, having an average width of 200 miles, and extending from the extremity of the Kurdistan Mountains to the mouth of the Indus. The Lazistân Mountains, which form the northern part of this belt, and bound the vast level plains of the Tigris, rise from it in a succession of high table-lands divided by very rugged mountains, the last ridge of which, mostly covered with snow, abuts on the table-land of Persia. Oaks clothe their flanks; the valleys are fertile, verdant, and cultivated; and many rivers flow through them to swell the stream of the Tigris. Insulated hill-forts, from 2000 to 5000 feet high, occur in this region, on flat cultivated summits some miles in extent, often accessible only by ladders, or holes cut in their precipitous sides. These countries abound in ancient inscriptions and remains of antiquity. The moisture decreases more and more as we proceed S. from Shiraz; and then the parallel ridges, repulsive in aspect and difficult to pass, are separated by arid longitudinal valleys, which ascend like steps from the narrow shores of the Persian Gulf to the table-land. The coasts of the gulf are burning sandy solitudes, so completely barren that the country from Bassora to the Indus, a distance of 1200 miles, is nearly a sterile waste. In a few favoured spots on the terraces, but only where water occurs, there is vegetation; and the beauty of these valleys is enhanced by surrounding sterility.[1]

With the exception of Mazanderan and the other provinces bordering upon the Caspian, and in the Paropamisan range, Persia is an arid region, possessing few perennial springs, and not one great river. In fact, three-tenths of the country is a desert, and the table-land is nearly a wide scene of desolation. A great salt desert occupies 27,000 square miles between Irak and Khorassan, of which the soil is a stiff clay, covered with efflorescence of common salt and nitre, often an inch thick, varied only by a few saline plants and patches of verdure in the hollows. This dreary waste joins the large sandy and equally dreary desert of Kerman. Kelat, the capital of Beluchistan, is 7000 feet above the level of the sea: round it there is cultivation, but the greater part of that country is a desert plain, over which the brick-red sand is drifted by the wind into ridges like the waves of the sea, often 12 feet high, without a vestige of vegetation. The blast of the desert, whose hot and pestilential breath is fatal to man and animals, renders these dismal sands impassable at certain seasons.

Barren lands or bleak downs prevail at the foot of the Lukee and Solimaun ranges, which are formed of bare porphyry and sandstone, and which skirt the eastern edge of the table-land, and dip to the plains bordering on the Indus. In Afghanistan there is little cultivation except on the banks of the streams that flow into the Seistan Lake, but fertility reappears towards the N.E. The plains and valleys among the offsets from the Hindoo Coosh are of surpassing loveliness, and combine the richest peaceful beauty with the majesty of the snow-capped mountains by which they are encircled.

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[1] Sir John Malcolm on Persia, and Mr. Morier's Travels.

§ 7. The elevated chain of the Hindoo Coosh, which occupies the terrestrial isthmus between the low lands of Hindostan and Bokhara, takes its name from a mountain 20,000 feet above the level of the sea, north of the city of Cabul. To the west, this chain is very broad, extending over many degrees of latitude, and covering the countries of Kafiristan, Kunduz, and Badakhshan, with its offsets. From the plains to the S. it seems to consist of four distinct ranges rising one above another, the last of which is so high that its snowy summits are visible at the distance of 150 miles. A ridge of considerable height encloses the beautiful valley of Cashmere, at the extremity of which the Himalaya may be said to begin. The passes over the Hindoo Coosh are mere defiles. There are six from Cabul to the plains of western Turkistan; and so deep and so much enclosed are they, that Sir Alexander Burnes never could obtain an observation of the pole-star during the whole journey from Bamian till within 30 miles of Turkistan.

CHAPTER V.

HIGH LANDS OF THE GREAT CONTINENT.—*continued.*

§ 1. Eastern Asiatic table-land. § 2. The Himalaya; glaciers; snow-line; passes; desolate plains. § 3. River-system of Tibet. § 4. Geology of the mountains of Tibet; salt lakes. § 5. Eastern Tibet; provinces of Yarkand and Khotan. § 6. Desert of Great Gobi. § 7. Altaï chain. § 8. Sayansk, Tangnou, and Ulangomula branches; minerals of the Altaï range. § 9. Geological character of the high lands of the Old Continent.

§ 1. THE great table-land of Eastern Asia extends through 30 degrees of longitude from the sources of the Oxus to those of the Hoang-Ho or Yellow River of China. The height of this enormous protuberance is small to the N. compared with that of Tibet which forms its summit, the lofty plain of which rises to the mean elevation of from 15,000 to 16,000 feet above the sea along its southern edge, next to the Himalaya. The Himalaya bounds Tibet on the S., but has no existence as a separate chain of mountains unconnected with the table-land; the peaks merely form protuberances on its southern face; but the Kuen-lun, which bounds Tibet on the N., has all the characters of an independent lofty chain, and according to the recent journey of a pundit employed by Captain Montgomerie of the Indian Trigonometrical Survey, a snowy chain, probably still more lofty, traverses Tibet E. and W., a little N. of the Tsan-po river. The central part of the plateau, on which are situated Yarkand, Khotan, and other cities, is of much less elevation than Tibet, being from 4000 to 6000 feet above the sea-level. It is bounded on the N. by the Thian-shan or Celestial Mountains, to the N.E. of which Mongolia and the desert of the Great Gobi are not more than 3000 feet above the level of the sea, and are bounded by the mountains which terminate the table-land on the N., separating it from the plains of Siberia. The table-land and all these mountains run nearly from W. to E., nevertheless the Altaï and Himalaya diverge in their eastern course, so that the table-land, which is only 700 or 1000 miles wide at its western extremity, is 1000 between the Chinese province of Yunnan and the country of the Manchoo Tonguses.

This elevated mass of table-lands and mountains ends abruptly about 71° 30′ E. long., where the lofty chain of the Bolor, or Cloudy Mountains, detaches itself from the Hindoo Coosh, and, running N. to join the Thian-shan, divides Eastern from Western Turkistan. In the centre of this little known mountain range lies the table-land of Pamir, called by the natives the Bain-y Dunya, or "Roof of the World." Its great elevation was made known by the celebrated Venetian traveller Marco Polo six centuries ago; although his account is too vague for the needs of modern geographers. It forms the watershed of this part of central Asia; the Amu or Oxus issuing from the western extremity of the small Alpine lake, Sir-i-Kol, situated on this elevated plateau, and the rivers of Yarkand and Kokan rising towards the eastern side, which is intensely cold in winter, but in summer is covered with flocks of sheep and goats.[1] From here the table-land of Tibet sinks down by a succession of terraces through the countries of Bokhara and Balkh to the deep cavity in which the Caspian Sea lies. Two narrow difficult passes lead over the Bolor Tagh from the low plains of Western Turkistan to Kashgar and Yarkand on the table-land of Eastern Turkistan.

§ 2. The table-land, and consequently the Himalaya, run from N.W. to S.E. from the débouche of the Indus to that of the Brahmapootra, and along that line there extends the vast unbroken plain of Hindostan, which is prolonged southward to the Bay of Bengal on one hand, while on the other it extends along the foot of the Himalaya, where it is 1200 feet above the level of the sea. The transition from the plain to the mountains is sudden. The Siwalik hills or sub-Himalayan range rise abruptly from the perfectly flat country; their height varies from a few hundred to 3000 or 4000 feet, and they run along the whole southern edge of the Himalaya. They present a steep face towards the plains, while they slope gently inwards and form a shallow valley between them and the next line of mountains, which runs parallel, but at a distance of from five to ten miles. This longitudinal depression is broken into short separate valleys by occasional junctions of the parallel ranges of hills. East of the Ganges it becomes a pestilential swamp, covered with reeds and grasses. It is followed on the N. by a band about 10 miles broad, generally covered by forest and remarkable for want of water. Here a range of mountains 7000 feet high runs parallel to the Siwalik hills, N. of which lie the peaceful and well-cultivated valleys of Nepaul, Sikim, Bhotan, and Assam, interspersed with picturesque and populous towns and villages. Behind these again are mountains from 10,000 to 12,000 feet high, flanked by magnificent forests, and then the chain rises rather abruptly, and form the wonderful range of the elevated Himalaya, the "Dwelling of Snow," which surpasses in height all other parts of the earth's surface.

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[1] Lieut. Wood's Journey to the Source of the River Oxus. 1 vol. 8vo.

The mean height of the Himalaya is very great (15,670 feet, according to Humboldt). Captain Gerard and his brother estimated that it could not be less than 20,000 feet: the peaks exceeding that elevation are not to be numbered, especially near the sources of the Sutlej and Ganges. Indeed, from that river to the Kalee the chain exhibits an endless succession of some of the loftiest mountains on earth; 40 of them surpass the height of Chimborazo, one of the most celebrated of the Andes, and several in Kumaon and Garhwal exceed 23,000 feet; but the highest of all—Mount Everest, between Nepaul and Sikim—is 29,002 feet above the level of the sea according to the measurements of Colonel (now General Sir Andrew) Waugh. The greatest peaks are generally 80 or 90 miles from the southern edge of the chain, and are not found in a continuous ridge, but grouped together in masses separated by deep depressions, through which the streams flow that drain these parts of the mountains. Captain Strachey mentions that in Kanor there is a small table-land the counterpart of Pamir; on both there is a lake 15,000 feet above the level of the sea, imbedded in mountains 19,000 feet high, with the same fauna of the domestic yak and wild sheep. The descent to the plains of India is extremely rapid from the table-land, especially in Bhotan, being more than 10,000 feet in 10 miles. The valleys are mere crevices, so deep and narrow, and the mountains that overhang in menacing cliffs so lofty, that these abysses are shrouded in perpetual gloom, except where the rays of a vertical sun penetrate their depths, and from the steepness of descent the rivers shoot down with the swiftness of an arrow, filling the caverns with foam and the air with mist.

The valleys between the snowy peaks are little more than gigantic ravines, with streams flowing in narrow channels, which at intervals open out into alluvial flats capable of agriculture. After passing the line in which the great peaks are situated, the ascent and the elevation of the bottoms of the valleys become very rapid, which shows that the sudden increase in the height of the mountains in that line is not confined to the peaks, but is a general elevation of the whole mass.

The Himalayan range N. of the Punjaub has been described by a recent traveller, Mr. Forsyth, as consisting of three parts, the "outer, mid, and trans-Himalaya." The outer Himalaya comprises all the low hills, higher slopes and ranges which face the plain of India. Splendid forests of timber and rich vegetation cover these portions almost up to the snow-line. The monsoons bring rain which washes the hill-sides, and the construction of a road is thus rendered very difficult. In the mid-Himalaya vegetation is scant, there are no forests; glaciers, and snowy peaks are everywhere to be seen; snow falls instead of rain, and avalanches are of hourly occurrence. The trans-Himalayan district has mountains of a rounded form, the extreme dryness of the atmosphere preserving the slopes from being cut into ravines. The passes cross by easy ascents and descents from one elevated plain to another.

The glaciers in the Himalaya are numerous and very large, yet till comparatively lately they were not supposed to exist. Captain Godwin-Austen of the Indian Trigonometrical Survey, to whom was allotted the rugged district of Baltistan, at the great northern bend of the Upper Indus, examined one glacier, the "Biafo Ganze," which was upwards of 60 miles in length, and (in lat. 35°) terminated at an elevation of 10,145 feet. The lowest level to which any is known to descend is 10,000 feet above the sea-level, but 12,000 feet is the more usual elevation of their extremities on the S. declivity. On the N. side of the mountains they terminate at about 16,000 feet, and their motion is analogous to that of the glaciers observed in the Alps.

According to Mr. Strachey the snow-line on the S. of the Himalayan mountains is at a height of 15,500 feet; while, on account of the dryness of the atmosphere, it ascends to 19,000 or 20,000 on the N. of the chain.

The Himalaya still maintains great height along the N. of Assam; and where the Brahmapootra cuts through it, the parent stem and its branches extend in breadth over 2° of latitude; but E. of this point ranges of mountains succeed, having a N. and S. direction, through the narrow valleys between which descend the Irrawady and other rivers of Indo-China lying between the Brahmapootra and the Yang-tsze-Kiang.

Nature has in mercy mitigated the intense rigour of the cold in these high lands in a degree unexampled in other mountainous regions. The climate is mild, the valleys are verdant and inhabited, corn and fruit ripen at elevations which in other countries—even under the equator—would be buried in permanent snow.

It is also a peculiarity in these mountains that, the higher the range, the higher likewise is the limit of snow and vegetation. On the southern slopes of the first range Mr. Gerard found cultivation 10,000 feet above the sea, though it was often necessary to reap the corn still green and unripe; while in Chinese Tartary crops of barley are raised 16,000 feet above the sea. Captain Gerard saw pasture and low bushes up to 17,009 feet; and corn as high as even 18,544 feet, which is 2800 feet higher than the top of Mont Blanc, and 1279 feet above the snow-line in the province of Quito under the equator. Birch-trees with tall stems grow at the elevation of 14,068 feet and the vine and other fruits thrive in the valleys of these high plains. The temperature of the earth has probably some influence on the vegetation; as many hot springs exist in the Himalaya at great heights, there must be a source of heat beneath these mountains, which in some places comes near the surface. Hot springs abound in the valley of Jumnotra; and as it is well known that many plants thrive in very cold air if their roots are well protected, this may be the cause of pine-trees thriving at great elevations in that valley, and of the splendid forests of the Deodar, a species of cedar that grows to a gigantic size even to the verge of the snow-line.

Most of the passes over the Himalaya are but little lower than the top of Mont Blanc; many are higher, especially near the Sutlej, where they are from 18,000 to 19,000 feet high. The Mustagh is about 18,400 feet, the Karakorum pass is 18,317 feet, the Yangi pass over the Kuen-lun into the plains of Ilchi is 19,092 feet. All are difficult, but the difficulty is much lessened in the case of the passes leading from Ladakh into Eastern Turkistan, owing to the dryness of the climate. Caravans now cross over passes from 17,000 to 19,000 feet in height. On the road from Leh to Yarkand, over the Karakorum, 20 per cent. of the animals die on the road, and for 5 or 6 days neither grass nor fuel is found. But the Changchenmo route from Leh to Ilchi, which at one place goes over a pass 19,000 feet above the sea, presents no such difficulties to traders as that over the Karakorum pass. Grass, wood, and water are found everywhere; and this route, or a modification of it, is soon likely to be extensively used in conveying Kangra tea and other goods to Yarkand, and reviving a trade which existed for ages before the British occupation of India. Other passes to the S. and S.W. are not so easy. The Niti pass, by which Moorcroft ascended to the sacred lakes of R'akas and Manasarowar in Tibet, is extremely difficult. He and his guide had not only to walk barefooted, from the risk of slipping, but they were obliged to creep along the most frightful chasms, holding by twigs and tufts of grass, and sometimes they crossed deep and awful crevices on the branch of a tree, or on loose stones thrown across.

The loftiest peaks, being precipitous, and therefore bare of snow, give great variety and beauty to the scenery, which in these passes is at all times magnificent. During the day, the stupendous mass of the mountains, their interminable extent, the variety and sharpness of their forms, and, above all, the clearness of their distant outline melting into the pale blue sky, contrasted with the deep azure above, is described as a scene of wild and wonderful beauty. At midnight, when myriads of stars sparkle in the black sky, and the pure blue of the mountains looks deeper still, below the white gleam of the earth and snow-light, the effect is of unparalleled grandeur, and no language can describe the splendour of the sunbeams at day-break streaming between the high peaks and throwing their gigantic shadows on the mountains below. There, far above the habitation of man, no living thing exists, no sound is heard; the very echo of the traveller's footsteps startles him in the awful solitude and silence that reign in these august dwellings of everlasting snow.

On arriving at the table-land by the Niti pass a traveller finds himself on a wide-spreading plain, stretching to the N.W. as far as the eye can reach, without sign of water, vegetation, or animal life. Behind rise mountains that fade away in the distance, with here and there only a peak covered with snow. These mountains are by no means so high as the Himalaya on the S. of the plain, yet they contain the Kailas, 22,000 feet high, and another 20,500. The plain varies in height from 10,000 to 15,000 feet above the sea. Moorcroft gives the following account of it. "In summer the sun is powerful at midday, the air is of the purest transparency, and the azure of the sky so deep that it seems black as in the darkest night. The rising moon does not enlighten the atmosphere, no warning radiance announces her approach till her limb touches the horizon, and the stars shine with the distinctness and brilliancy of suns. In southern Tibet the verdure is confined to favoured spots; the bleak mountains and high plains are sternly gloomy, a scene of barrenness not to be conceived. Solitude reigns in these dreary wastes, where there is not a tree nor even a shrub to be seen of more than a few inches high. The scanty short-lived verdure vanishes in October: the country looks then as if fire had passed over it, and cutting dry winds blow with irresistible fury, howling in the bare mountains, whirling the snow through the air, and freezing to death the unfortunate traveller benighted in these regions." This plain consists of two parts: that to the east, which is much encroached upon by mountains, contains the lakes R'akas and Manasarowar, celebrated in the sacred legends of the Hindus. They lie in a deep recess at the foot of the Gangri mountains, at an elevation of 15,000 feet. "The islands and innumerable headlands of the former, the intensely lovely blue of its waters, with its snowy breakers, and Kailas's snowy dome in the background, formed a scene of uncommon beauty, marred, however, by utter desolation and southern blasts that chill to the bone."

To the W. this desolate plain is much broader and more extensive; it is 15,000 feet high in its central part, and is cut through by the Sutlej, which issues from the R'akas lake and flows at the bottom of a deep ravine furrowed out of the alluvial matter of the plain to a depth of 3000 feet. Ravines, the slopes of which are often almost as even and straight as a railway cutting, for miles together intersect this plain of Guge. One mentioned by Captain Strachey is about a mile deep; and their extraordinary magnitude is such that Moorcroft talks of their slopes as mountains overhanging the plain out of which they are cut. Captain Strachey describes Western Tibet as consisting of a dense mass of huge rocky mountains, whose habitable, or even accessible, valleys bear but a small proportion to the solid mass of mountains too steep and high for any human use. The loftier summits rise in all quarters to an elevation of four miles above the sea, a few of the highest yet measured are nearly five, and the mean elevation about 20,000 feet. The mountains, however, are by no means disposed in a confused mass; they extend from N.N.W. to S.S.E. in regular parallel chains separated by long valleys, in which flow the upper courses of the Indus and Brahmapootra rivers. The pundit employed by Captain Montgomerie to execute a reconnaissance survey of this region travelled along the Jong-lam, or great high road, by means of which the Chinese officials keep up their communications between Lhasa and Gartokh, N.E. of the R'akas and Manasarowar Lakes. The distance is 800 miles, and the average elevation of the road 13,500 feet above the sea-level; only for one stage the road descended so low as 11,000 feet, whilst at several passes it ascended to more than 16,000 feet. The great river Tsan-po, supposed to be the upper course of the Brahmapootra, and which runs from W. to E. is occasionally crossed by this road, and its waters lie at an elevation of 11,800 feet at Shigatze, S.W. of Lhasa.

Glaciers are rare in Tibet on account of the dryness of the air, and lie mostly on the N. side of the Himalaya, and on the western part of the Karakorum range, where they are very extensive. But notwithstanding the severity of the climate, the Tibetans cross the passes, which are between 18,000 and 19,000 feet high, even in winter.

§ 3. The river system is one of the principal features of Tibet. The watershed of the Indus and Brahmapootra is a transverse ridge that runs N. from the Himalaya to the Karakorum, which divides the country into two basins of drainage. The major axis of both rivers lies parallel to the longer axis of the table-land till they attain the extremities of Indian Tibet, where they turn sharply and flow in deep crevices to the plains of India. These two great streams, together with the Sutlej, are the only rivers of Tibetan origin that water the plains of Hindostan; all the rest come from the Himalayan watershed, which is 25 miles to the N. of the line of the great snowy peaks, or from the face of the mountains.

Rain is hardly known in Tibet, and the whole amount of snow that fell during two years that Captain Strachey spent at Leh was little more than 20 inches. The snow does not lie on the arid stony soil. There is a total absence of thunder and lightning, and the air so completely loses its conducting power that a person clothed in sheepskins becomes so highly charged as to give out long sparks on touching a conducting substance.

Even in these elevated regions wheat and barley grow in sheltered places, where there is irrigation, and many of the fruits of southern Europe ripen. Round the villages, barley, peas, and beans are grown; and the eye rests with pleasure on groves of walnut, apricot, mulberry, poplar, and willow. The city of Lhasa in Eastern Tibet, the residence of the Grand Lama, is surrounded by vineyards, and is called the "Realm of Pleasure." There are some trees, but the ground in cultivation in Eastern Tibet bears a small proportion to the grassy steppes, which extend in endless monotony, grazed by thousands of the shawl-wool goats, sheep, and cattle.

§ 4. From the parallelism of the mountain chains in Tibet, that of the line of greatest elevation of the Himalayan peaks, and of the ridge of low hills at their base, Captain Strachey infers that the whole mass has been raised from the bottom of the ocean by one general agency, which is confirmed by its geological structure. The quantity of granite is small, and very rarely expands into mountain masses. Stratified crystalline rocks, especially gneiss, form the crest of the Himalaya and mountains in Tibet, and in both Palæozoic beds immediately succeed the crystalline. But the most remarkable feature of these high lands is, that the plain of Tibet is of comparatively recent origin, consisting of a deposit of boulders and gravel in horizontal strata, rising to an elevation of about 15,000 feet without any sensible disturbance. In the plain of Guge bones of the elephant, rhinoceros, horse, and a new species of ruminants occur in this deposit; creatures whose existence would be a physical impossibility in the present climate; so that it is necessary to suppose they were elevated from a lower situation by some great geological cataclysm. A very long line of the older fossiliferous rocks about 20 or 30 miles N. of the great Himalayan peaks must have been a sea margin from the earliest periods of the earth's history till as late as the oolitic periods. Tertiary strata occur in the Niti pass 17,000 feet above the sea, and even higher still, and probably the plain of Tibet was raised above the sea to its present position since the tertiary period. There had been a great volcanic outburst near the sacred lakes. Hot springs are frequent both to the S. and N. of the line of great peaks.

There are many salt lakes in Tibet; that of Pangong, or rather the chain of Pangong lakes, having an area of 6500 square miles, lies in a serpentine form at the foot of the Karakorum mountains, and occupies a valley more than 100 miles long, bounded on the southern side by high, rocky, snow-capped mountains, and on the N. by low rounded hills. The waters of the lake are of a deep blue, and the hills present every variety of lovely and brilliant colouring. Boracic acid exists in abundance in the hot springs of Central Tuscany, and in an extinct crater in the island of Volcano, but Tibet is the only country in the world where native tincal or borate of soda is found.

§ 5. Of Eastern Tibet by much the greater half remains to be explored, and the Kuen-lun, which bounds Tibet on the N., is not well known. It extends eastward from the mountain-knot of the Tsung-ling in two branches, which surround lake Tengri-nor, and again unite in the K'han of Eastern Tibet. The Karakorum, or Ice Mountains, are the most southerly branch, and chains, more or less connected with these, form an elevated mountain mass round lake Koko-Nor, nearly in the centre of the table-land from whence those immense mountain ranges diverge which render the south-western provinces of China amongst the most elevated regions on earth.[1]

Yarkand and Khotan, provinces of Eastern Turkistan, lie to the N. of the Kuen-lun. They are less elevated and more fertile than Tibet; yet it is so cold in winter that the river Yarkand is frozen for three months. The soil is generally sandy and free from stones and rocks. It is very productive; Indian corn, wheat, barley, buckwheat, and rice grow in perfection; olives, pears, apples, peaches. apricots, mulberries, grapes, currants, and melons are produced of good size and flavour; cotton and raw silk abound. A dense forest stretches for 12 marches between Khotan and Aksu, two of the chief towns. Gold is found in large quantities in the beds of the streams which flow from the Kuen-lun, and thousands of men are at work on the gold-fields. The plains are watered by the Kashgar, Yarkand, Khotan, and Kiria rivers which unite to form the Tarim. Several large cities, of which the chief are Yarkand, Ilchi, Kashgar, and Aksu, exist. Yarkand, the most considerable of these, is the emporium of commerce between Tibet, China, Turkistan, Bokhara, Persia, and Russia. Gold, rubies, silk, and other productions are exported. This country is bounded on the N. by the Tartar range of the Thian-shan, or Celestial Mountains, which begins at the northern extremity of the Bolor, and, running along the 42nd parallel of latitude, sinks to the desert of the Great Gobi, about the centre of the table-land, but, rising again, they are continued under the name of Shan-Garjan, which runs to the N.E. and ends on the shores of the Japan Sea. This range is of great altitude; the Bogda Oola, or "Holy Mountain," near lake Lop, is always covered with snow, which lies deep on the whole chain during the winter, yet little falls on the plains on account of the dryness of the air. There are only two or three showers of rain annually on these mountains, which last for a very short time, and, as in Tibet, the drops are so minute as scarcely to wet the ground, yet the streams from them suffice for irrigation.

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[1] The authorities for the matter contained in this chapter are Baron Humboldt, 'Asie Centrale;' Mr. Keith Johnston's 'Physical Atlas;' Captain Strachey on 'Western Tibet;' Mr. Moorcroft on 'Journey in Tibet;' Dr. Thomson on 'Western Himalaya;' Dr. Joseph Hooker on 'Sikhim and Nepaul;' the numerous papers published by the officers of the Trigonometrical Survey of India, under the able direction of Colonel Waugh, and by others in the Journal of the Asiatic Society of Calcutta; and the journeys of the missionaries Huc and Gabet in 'Eastern Tibet.'

In Tibet granite and Palæozoic strata prevail without any indication of volcanic action, except hot springs, of which there are many. The country between the Thian-shan and the Altaï is hardly known farther than that grassy steppes, intersected by many lakes and offsets from the Altaï, are the pasture-grounds of the wandering Kirghis. All the plains of Mongolia are intensely cold in winter, because the hills to the N. are too low to screen them from the polar blast, and, being higher than the Siberian deserts, they are bitterly cold: no month in the year is free from frost and snow, yet it is not deep enough to prevent cattle from finding pasture.

§ 6. The most remarkable feature of this part of the table-land is the desert of the Great Gobi, which is evidently the bed of a dried-up lake. It occupies an area of 300,000 square miles interrupted only by a few spots of pasture and low bushes. Extensive tracts are flat and covered with small stones or sand, and, widely separated from one another, are low hills destitute of wood and water Its general elevation is 4220 or 3000 feet above the level of the sea; but it is intersected from W. to E. by a depressed valley, aptly named Shamo, or the "Sea of Sand," containing salt. W. from this lies the Han-Hai, the "Dry Sea," a barren plain of shifting sand blown into high ridges. Here, as in all deserts, the summer sun is scorching, no rain falls, and when thick fog occurs it is only the precursor of fierce winds. Sandy deserts occupy much of the country S. of the Chinese branches of the Altaï. The Great Gobi is bounded on the E. by the In-shan and Khing-han mountains, a serrated granitic chain running from S. to N., which separates the plateau of Mongolia from the country of Manchouria, and joins the Yablonnoi branch of the Altaï at right angles about the 55th degree of N. latitude. Little more is known of the south-eastern part of the table-land than that it is a mass of exceedingly high mountains. In fact, between the sources of the Brahmapootra and the Altaï chain, 1,000,000 square miles of the Chinese empire are covered with mountains.

The extreme dryness of all the table-land N. of the Himalaya arises from the direction of the winds and the great height of these mountains and the southern part of the table-land in general. The prevailing winds come warm and moist from the Indian Ocean, and their vapour is more and more condensed into rain, as they pass over the plains of India and the lower ranges of the Himalaya, till the last remains of moisture fall in snow on the tops of these mountains, so that they pass to the N. as dry rainless winds.

§ 7. The Altaï mountains, which form the northern margin of the table-land, are unconnected with the Ural chain: they are separated from it by 400 miles of a low marshy country, part of the steppe of the Kirghiz, and by the Dalaï mountains, a range never exceeding 2000 feet in height, which runs between the 64th meridian and the left bank of the Irtish. The Altaï chain rises on the right bank of that river, at the N.W. angle of the table-land, and extends in a serpentine line to the Pacific, south of the Gulf of Okhotsk, dividing the high lands of Tartary and China from the wastes of Asiatic Siberia. Under various names, its branches skirt the N.W. side of the Sea of Okhotsk; and thence stretching to Behring Strait, it ends at East Cape, the most eastern extremity of the old continent, the whole length of the chain being 4500 miles. The breadth of this chain varies from 400 to 1000 miles, but towards the 105th meridian it is contracted to about 150 by a projection of the desert of the Great Gobi. Its height bears no proportion to its length and breadth. The Altaï, the only part of the chain properly so called, consists of a succession of terraces of a swelling outline, descending step by step from the table-land, and ending in promontories on the Siberian plains. There are numerous large lakes on these terraces and in the valleys, as in the mountain systems of Europe. The general form of this part of the chain is monotonous from the prevalence of straight lines and smooth rounded outlines—long ridges with flattened summits or small table-lands not more than 6000 feet high, which rarely attain the line of perpetual congelation; snow, however, is permanent on the Korgon table-land, 9900 feet above the sea, supposed to be the culminating point of this part of the chain. These table-lands bear a strong resemblance to those in the Scandinavian mountains in barrenness and sterility, but their flanks are clothed with forests, verdant meadows, and pastoral valleys.

§ 8. East of the 86th meridian this region of low mountains splits into three branches, enclosing longitudinal valleys for 450 miles. The Sayansk and Tangnou mountains, which are the northern and central branches, form a mountain-knot nearly as large as England, which projects like a huge promontory on the Siberian plains[1] west of Lake Baikal, and is celebrated for the richness of its mines. The third branch, which is the Ulangomula, lies S. of Lake Oubsa. The principal part of the Baikal group is 500 miles long, from 10 to 60 wide, high, and snow-capped, and said to be without glaciers. It flanks Lake Baikal on the N., the largest of Alpine lakes, so embedded in a knot of mountains, partly granitic, partly volcanic, that rocks and pillars of granite rise from its bed. The mountains south of the lake are but the face of the table-land; a traveller ascending them finds himself at once on the desert of Gobi, which stretches in unbroken monotony to the great wall of China.

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[1] Johnston's 'Physical Atlas.'

The Daouria mountains, a volcanic portion of the Altaï, which borders the table-land on the N.E., follow the Baikal chain; and farther E, at the sources of the Aldan, the Altaï range takes the name of the Yablonnoi Khrebet, which runs N.N.E. till about the 126th meridian, where one branch turns sharp to the E., and stretches south of the Gulf of Okhotsk to the coast of the Pacific opposite to the island of Saghalien; while another part, 1000 miles broad, fills the space between the Sea of Okhotsk and the river Lena, and then, bending to the N.E., ends in the peninsula of Kamtchatka. Between the western end of Lake Baikal and the Yablonnoi Khrebet the mountain chains are parallel, and extend from the W.S.W. to the E.N.E., which is the general direction of the high lands in the most easterly regions of Asia.

A great part of the Altaï chain is unknown to Europeans; the innumerable branches that penetrate the Chinese empire are completely so; those belonging to Russia abound in a great variety of precious and rare metals and minerals —silver, copper, and iron. In the Yablonnoi range and other parts there are mountains of porphyry, with red and green jasper; coal is also found; and in a branch of the Altaï between the rivers Obi and Yenisei there are mines of coal which, having been set on fire by lightning, have continued to burn for more than a century. The Siberian mountains far surpass the Andes in the richness of their gold-mines, though inferior to those of California and Australia. The eastern flank of the Ural chain, and some of the northern spurs of the Altaï, have furnished a vast quantity of that precious metal; but a region as large as France, has been discovered in Siberia covered with rich gold alluvium. The precious metals of the Ural and Altaï are situated principally in metamorphic rocks, adjacent to the greenstones, syenites, and serpentines that have caused their change; and as the same formation prevails throughout the greater part of the Altaï and Aldan chains almost to Kamtchatka, there is every reason to believe that the whole of that vast region is auriferous: besides, as many of the northern offsets of the Altaï are particularly rich, it may be concluded that the southern branches in the Chinese empire are equally so. Thus southern Siberia and Eastern Turkistan form an auriferous district, probably greater in area than all Europe, which extends even to our dominions in Hindostan, where the formations containing auriferous deposits are unexplored.[1]

§ 9. The sedimentary deposits in this extensive mountain-range are more ancient than the granite, syenite, and porphyries; consequently these igneous rocks have not here formed part of the original crust of the globe. Rocks of the Palæozoic series occupy the greater part of the Altaï, and probably there are none more modern. There are no volcanic rocks properly speaking, ancient or modern, west of the Yenisei; but they abound from that river to Kamtchatka, where there are many active volcanoes.

The physical characters and the fossil remains of this extensive mountain system have little relation with the geological formations of Europe and America. Eastern Siberia seems even to form an insulated district by itself; and that part between the town of Yakutsk and the mouth of the Lena appears to have been raised at a later period than the part of Siberia stretching westward to the Sayansk mountains; moreover the most distinguished geologists have found that the low land of Siberia has been extended since the existing species of mollusca inhabited the northern seas—a circumstance that must have rendered the Siberian climate still more severe, and materially affected that of all the northern parts of Europe and Asia.[2] The elevation of the western part of the Altaï was probably contemporaneous with that of the Ural mountains. On the whole, the chains in the direction of parallels of latitude in the old continent are much more numerous and extensive than those in the direction of the meridian; and as they lie chiefly towards the equator, the internal forces that raised them were probably modified by the rotation of the earth.

Such is the stupendous zone of high land that girds the old continent throughout its whole length. In the extensive plains on each side of it several independent mountain systems rise, though much inferior to it in extent and height.

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[1] Sir Roderick I. Murchison.

[2] From the observations of Sir Roderick I. Murchison, M. de Verneuil, M. Middendorf, and Count Keyserling.

CHAPTER VI.

SECONDARY MOUNTAIN SYSTEMS OF THE GREAT CONTINENT.

§ 1. The Scandinavian system; coast of Norway; Faröe Islands. § 2. Mountains of Great Britain and Ireland. § 3. Geological uniformity of the Scandinavian and British mountain systems. § 4. Ural chain. § 5. Great Northern plain; pastures, waste lands, steppes; Turkistan; Siberia; climate and productions.

§ 1. THE Great Northern plain is broken by two masses of high land, in every respect inferior to those described; they are the Scandinavian system and the Ural mountains, the latter forming the arbitrary limit between Europe and Asia.

The range of primary mountains which has given its form to the Scandinavian peninsula begins at Cape Lindesnaes, the most southerly point of Norway, and, after running along its western coast 1000 miles in a north-easterly direction, ends at Cape North, the extremity of Europe, on the Polar Ocean. The mountains do not form a continued ridge or chain, but a series of broad plateaux separated at wide intervals by deep and narrow valleys. The most characteristic of these table-lands is the Dovre-fjeld, 3000 feet high, on which Sneehätten rises to 7620 feet. In the northern and narrower part of the peninsula the Kiolen mountains assume more the form of a ridge, rising in Mount Sulitelma to 6200 feet (lat 67° 30′), whence it falls in the north, till at the North Cape it is only 1500 feet. It has been compared to a huge wave or billow, rising gradually from the E., which, after having formed a crest, falls perpendicularly into the sea in the W. It is estimated that nearly 4000 square miles of this peninsula rise above the line of perpetual snow.

At the distance of 360 miles from Cape Lindesnaes the mountains form a single elevated mass, terminated by a table-land which maintains an altitude of 4500 feet for 100 miles. It slopes gradually towards the E., and plunges at once in high precipices into a deep sea on the W.

The surface is barren, marshy, and bristled with peaks; besides, an area of 600 square leagues is occupied by the Snae Braen, the most extensive continuous mass of perpetual snow and glaciers on the continent of Europe. A prominent cluster of mountains follows, from whence a single chain, 25 miles broad, maintains an uninterrupted line to the island of Mageröe, where it terminates its visible career in North Cape, a huge barren rock perpetually lashed by the surge of the Polar Ocean, but from the correspondence in geological structure it must be continued under the sea to where it reappears in the schistose rocks of Spitzbergen. Offsets from these mountains cover Finland and the low rocky table-land of Lapland; the valleys and countries along the eastern side of the chain abound in forests and Alpine lakes.

The iron-bound coast of Norway is a continued series of rocky islands, capes, promontories, and precipitous cliffs, rent into chasms, which penetrate miles into the heart of the mountains. These chasms, or fiords, are either partly or entirely filled by arms of the sea: in the former case the shores are fertile and inhabited, and the whole country abounds in the most picturesque scenery. Fiords are not peculiar to the coast of Norway; they are even more extensive in Greenland and Iceland, and of a more stern character, overhung by snow-clad rocks and glaciers.

As the Scandinavian mountains, those of Faröe, Britain, Ireland, and the north-eastern parts of Iceland, have a similar character, and follow the same general directions, they must have been elevated by forces acting in parallel lines, and therefore may be regarded as belonging to the same system.

The Faröe Islands, between Norway and Iceland, rise on a table-land 2000 feet high, bounded by precipitous cliffs which dip into the ocean.

§ 2. The two groups of rocky islands of Shetland and of Orkney form part of the mountain system of Scotland; the Orkney Islands have evidently been separated from the mainland by the Pentland Firth, where the currents run with prodigious violence. The north-western part of Scotland is a table-land from 1000 to 2000 feet high, which ends abruptly in the sea, covered with heath, peat-mosses, and pasture. The general direction of the Scottish mountains, like those of Scandinavia, is from N.E. to S.W., divided by a long line of lakes in the same direction, extending from the Moray Firth completely across the island to Loch Linnhe on the S.W. Lakes of the most picturesque beauty abound among the Scottish mountains. The Grampian hills, with their offsets and some low ranges, fill the greater part of Scotland north of the Clyde and Forth. Ben Nevis, only 4406 feet above the sea, is the highest mountain in the British Islands.

The E. coast of Scotland is generally bleak, though in many parts it is extremely fertile, and may be cited as a model of good cultivation; and the midland and southern counties are not inferior, either in the quality of the soil or the excellence of the husbandry. To the W. the country is wildly picturesque; the coast of the Atlantic, penetrated by the sea, which is covered with islands, bears a strong resemblance to that of Norway.

There cannot be a doubt that the Hebrides formed part of the mainland at some remote geological period, since they follow the direction of the mountain system in two parallel lines of islands of rugged and imposing aspect, never exceeding the height of 3200 feet. The undulating country on the borders of Scotland becomes higher in the W. of England and North Wales, where the hills are wild, but the valleys are cultivated like gardens, and the English lake scenery is of the most gentle beauty.

Evergreen Ireland is mostly a mountainous country, and opposes to the Atlantic storms an iron-bound coast of the wildest aspect; but it is rich in arable land and pasture, and possesses the most picturesque lake scenery. Indeed, freshwater lakes in the mountain valleys, so peculiarly characteristic of the European system, are the great ornaments of the high lands of Britain.

§ 3. The similarity in form of Scandinavia, and Scotland with its islands, and the north of Ireland, arises from the similarity in their geological structure, all being formed of crystalline rocks, mixed with volcanic ones. Even the older Palæozoic strata, which constitute the mountains of Norway, reappear in the midland and southern counties of Scotland, and in the N. of Ireland; and are developed on either side of St. George's Channel, and in Wales, where they are of enormous thickness. Almost the whole of Ireland, and the central parts of England, belong to the upper Palæozoic series; and the old red sandstone, many hundred feet thick, stretches from sea to sea along the flanks of the Grampians. The coal strata are developed on a great scale in the S. of Scotland and the N. of England. Examples of every formation, with the exception of the muschelkalk, are to be found in these islands. Volcanic fires had been very active in early times, and nowhere is the columnar structure more beautifully exhibited than in the basaltic cliffs of Fingal's Cave and the Storr of Skye, in the Hebrides; and in the N. of Ireland a base of 800 square miles of mica-slate is covered with volcanic rocks, which end on the coast in the magnificent columnar precipices of the Giant's Causeway. Various parts of the British Islands were dry land while most of the continent of Europe was yet below the ancient ocean. The high lands of Lammermuir and the Grampian Hills in Scotland, and those of Cumberland in England, were raised before the Alps had begun to appear above the waves.

§ 4. The Ural chain, the boundary between Europe and Asia, is the only interruption to the level of the great northern plain, and is altogether unconnected with, and far separated from, the Altaï mountains by salt lakes, marshes, and deserts. The central ridge may be traced from between the Lake of Aral and the Caspian Sea to the northern extremity of Novaia Zemlia, a distance of more than 1700 miles; but as a chain it really begins on the right bank of the Ural river, at the steppes of the Kirghiz, about the 51st degree of N. latitude, and runs due N. in a long narrow ridge to the Karskaïa Gulf of the Kara Sea, in the Polar Ocean, though it may be said to terminate in dreary rocks on the W. side of Novaia Zemlia. The southern portion of the Ural range is about the height of the mountains in the Black Forest and the Vosges; and, with few exceptions, it is wooded to the top, chiefly by the Pinus cembra. The great mineral riches of these mountains—gold, platina, magnetic iron, and copper—are situated on the Siberian declivity, and mostly between the 54th and 60th degrees of N. latitude: the only part that is colonized, and one of the most industrious and civilized regions of the Russian Empire. To the S. the chain is pastoral, about 100 miles broad, consisting of parallel and longitudinal ridges, the highest of which does not exceed 3,500 feet: in this portion diamonds are founds. The Northern Ural, which extends from the sources of the Petchora, and N. of Petropaulovsk, is still more elevated: it has been carefully explored by the Russian government as far as lat. 68° 30′, where is situated, perhaps, the highest peak of the chain, the Konstaninow Kamen: the average height is about 3000 feet; two of its peaks, the Töll Poss and Sabija, reach 5000; no part of it is covered with perpetual snow, although in the mountains of Norway, in the same latitude, the snow-line descends to 3000 feet. Throughout the Ural mountains there are neither precipices, transverse gorges, nor any of the characteristics of a high chain; the descent on both sides is so gentle that in many places it is difficult to know where the plain begins; and the road over the chain from Russia by Ekaterinburg is so low that it hardly seems to be a mountain-pass. The gentle descent and sluggishness of the streams produce extensive marshes along the Siberian base of the range. To the arduous researches of Sir Roderick Murchison and M. de Verneuil we were indebted for almost all we know of these mountains, until the late Russian expedition sent out at the instigation of the Geographical Society of St. Petersburg, under Colonel Hoffman. He found them, on the western side, to be composed of Silurian, Devonian, and carboniferous rocks, more or less altered and metamorphosed; on the eastern declivity the mines are in metamorphic strata, mixed with masses of igneous origin; and the central axis is of quartzose and chloritic rocks.

§ 5. The great zone of high land which extends along the old continent from the Atlantic to the shores of the Pacific Ocean divides the low lands into two very unequal parts. That to the north, only broken by the Ural range and the Valdai table-land of still less elevation, stretches from the Thames or the British hills and the northern bank of the Seine to Behring Strait, including more than 190 degrees of longitude, and occupying an area of about 5,300,000 English square miles at least, a third more than the whole of Europe. The greater part of it is perfectly level, with a few elevations and low hills, and in many places a dead level extends hundreds of miles. The country between the Carpathian and Ural mountains is a flat, on which there is scarcely a rise in 1500 miles; and in the steppes of southern Russia and Siberia the extent of level ground is immense. The mean height of the level provinces of France is 480 feet. Moscow, the highest point of the European plain, is also 480 feet high, from whence the land slopes imperceptibly towards the sea, both on the N. and S., till it dips below its level. Holland, on one side, would be overflowed, were it not for its dykes, and towards Astrakhan the plain sinks still lower. With the exception of the plateau of Ust-Urt, of no great elevation, situated between the Caspian and Aral, and which may be considered the extreme southern point of the Ural chain, the whole of that extensive country N. and E. of the Caspian Sea, and around the Lake of Aral, forms a vast cavity of 18,000 square leagues, all considerably below the level of the ocean; and the surface of the Caspian sea itself, the lowest point, has a depression exceeding 82 feet.

The European part of the plain is highly cultivated and very productive in the more civilized countries in its western and middle regions and along the Baltic. The greatest amount of cultivated land lies to the N. of the watershed which stretches from the Carpathians to the centre of the Ural chain, yet there are large heaths which extend from the extremity of Jutland through Luneburg and Westphalia to Belgium. The land is of excellent quality to the S. of it. Round Polkova and Moscow there is an extent of the finest vegetable mould, equal in size to France and the Spanish peninsula together, which forms part of the High Steppe, and is mostly in a state of nature.

A large portion of the great plain is pasture-land, and wide tracts are covered with natural forests, especially in Poland and Russia, where there are millions of acres of pine, fir, and deciduous trees.

The quantity of waste land in Europe is very great, and there are also many swamps. A morass as long as England extends from the 52nd parallel of latitude, following the course of the river Prepit, a branch of the Dnieper, which runs through its centre. There are swamps at the mouths of many of the sluggish rivers in Central Europe. They cover 1970 miles in Denmark, and mossy quagmires occur frequently in the more northerly parts.

Towards the eastern extremity of Europe the great plain assumes the peculiar character of desert called a *steppe*, a word supposed to be of Tartar origin, signifying a level waste destitute of trees: hence the steppes may vary according to the nature of the soil. They commence at the river Dnieper and extend along the shores of the Black Sea. They include all the country N. and E. of the Caspian Lake and Independent Tartary; and passing between the Ural and Altaï mountains, they may be said to occupy all the low lands of Siberia. Hundreds of leagues may be traversed E. from the Dnieper without variation of scene. A dead level of thin but luxuriant pasture, bounded only by the horizon, day after day the same unbroken monotony fatigues the eye. Sometimes there is the appearance of a lake, which vanishes on approach, the phantom of atmospheric refraction. Horses and cattle beyond number give some animation to the scene, so long as the steppes are green; but winter comes in October, and then they become a trackless field of spotless snow. Fearful storms rage, and the dry snow is driven by the gale with a violence which neither man nor animal can resist, while the sky is clear and the sun shines cold and bright above the earthly turmoil. The contest between spring and winter is long and severe, for

> "Winter oft at once resumes the breeze,
> Chills the pale morn, and bids his driving sleets
> Deform the day, delightless."

Yet when gentler gales succeed, and the waters run off in torrents through the channels which they cut in the soft soil, the earth is again verdant. The scorching summer's sun is as severe in its consequences in these wild regions as the winter's cold. In June the steppes are parched, no shower falls, nor does a drop of dew refresh the thirsty and rent earth. The sun rises and sets like a globe of fire, and during the day he is obscured by a thick mist from the evaporation. In some seasons the drought is excessive: the air is filled with dust in impalpable powder, the springs become dry, and cattle perish in thousands. Death triumphs over animal and vegetable nature, and desolation tracks the scene to the utmost verge of the horizon, a hideous wreck.

Much of this country is covered by an excellent but thin soil, fit for corn, which grows luxuriantly wherever it has been sown; but a stiff cold clay at a small distance below the surface kills every herb that has deep roots, and no plants thrive but those which can resist the extreme vicissitudes of climate. A very wide range is hopelessly barren. The country from the Caucasus, along the shores of the Black and Caspian Seas—a dead flat, twice the size of the British islands—is a desert destitute of fresh water. Saline efflorescences cover the surface like hoar-frost. Even the atmosphere is saline, and many salt lakes in the neighbourhood of Astrakhan furnish great quantities of common salt. Saline plants, with patches of verdure few and far between, are the only signs of vegetable life, but about Astrakhan there is soil and cultivation. Some low hills occur in the country between the Caspian and the Lake of Aral, the desert of Ust-Urt, but it is mostly an ocean of shifting sand, often driven by appalling whirlwinds.

Western Turkistan is a sandy desert, except on the banks of the Oxus, the Zariaf-shan, and the Jaxartes, and as far on each side of these rivers as canals can convey the fertilising waters. To the N., barrenness gives place to verdure between the river Ural and the mountains of Central Asia, where the steppes of the Kirghiz afford pasture to thousands of camels and cattle, the riches of these wandering hordes.

Siberia is either a dead level or undulating surface of vast extent lying between the North Pacific and the Ural mountains, the Polar Sea and the Altaï range, whose terraces and offsets end on these plains, like headlands and promontories in the ocean. M. Middendorf, indeed, met with a chain of most desolate mountains on the shores of the Polar Sea, in the country of the Samoiedes; and the almost unapproachable coast far to the E. is unexplored. The mineral riches of the mountains have brought together a population who inhabit towns of some importance along the base of the Ural and Altaï chains, where the soil yields good crops and pasture; and there are forests on the slopes of the mountains and on the plains. There are many hundred square miles of rich black mould covered with trees and grass uninhabited, between the river Tobol and the upper course of the Obi, within a climate where corn would grow; but this valuable district is studded with small lakes of salt and fresh water, a chain of which, 300 miles long, skirts the base of the Ural mountains.

North of the 62nd parallel of latitude corn does not ripen, on account of the biting blasts from the Icy Ocean which sweep supreme over these unprotected wastes. In a higher latitude even the interminable forests of gloomy firs are seen no more; all is a wide-spreading desolation of salt steppes, boundless swamps, and lakes of salt and fresh water. The cold is so intense there that the spongy soil is perpetually frozen to the depth of some hundred feet below the surface; and the surface itself, not thawed before the end of June, is again ice-bound by the middle of September, and deep snow covers the ground nine or ten months in the year. Happily gales of wind are not frequent during winter, but when they do occur no living being ventures to face them. Admiral Wrangel, who travelled during the most intense cold from the mouth of the river Kolyma to Behring Strait, gives an appalling account of these deserts. "Here endless snows and ice-covered rocks bound the horizon, nature lies shrouded in all but perpetual winter, life is a constant conflict with privation and with the terrors of cold and hunger—the grave of nature, which contains only the bones of another world. The people, and even the snow, smoke; and this evaporation is instantly changed into millions of needles of ice, which make a noise in the air like the sound of torn satin or thick silk. The reindeer take to the forest, or crowd together for heat; and the raven alone, the dark bird of winter, still cleaves the icy air with slow and heavy wing, leaving behind him a long line of thin vapour, marking the track of his solitary flight. The trunks of the thickest trees are rent with a loud noise, masses of rock are torn from their sites, the ground in the valleys is rent into yawning fissures, from which the waters that are underneath rise, giving off a cloud of vapour, and immediately become ice. The atmosphere becomes dense, and the glistening stars are dimmed. The dogs outside the huts of the Siberians burrow in the snow, and their howling at intervals of six or eight hours, interrupts the general silence of winter."[1] In many parts of Siberia, however, the sun, though long absent from these dismal regions, does not leave them to utter darkness. The extraordinary brilliancy of the stars, and the gleaming snowlight, produce a kind of twilight, which is augmented by the splendid coruscations of the aurora borealis.

The scorching heat of the summer's sun produces a change like magic on the southern provinces of the Siberian wilderness. The snow is scarcely gone before the ground is covered with verdure, and flowers of various hues blossom, bear their seed, and die in a few months, when winter again resumes its empire. A still shorter-lived vegetation scarcely covers the plains in the far north, and, on the shores of the Icy Sea, even reindeer moss grows scantily.

The abundance of fur-bearing animals in the less rigorous parts of the Siberian deserts has tempted the Russians to colonize and build towns on these frozen plains. Yakutsk, on the river Lena, in 62° 1′ 30″ N. lat., is probably the coldest town on the earth. The ground is perpetually frozen to the depth of more than 400 feet, of which three feet only are thawed in summer, when Fahrenheit's thermometer is frequently 77° in the shade; but as there is in some seasons no frost for four months, larch forests cover the ground, and wheat and rye produce from fifteen to forty fold. In winter the cold is so intense that mercury is constantly frozen for two months, and occasionally even for three.

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[1] In 1820 Admiral (then Lieutenant) Wrangel travelled from the mouth of the Kolyma to Behring Strait on sledges drawn by dogs, and made a bold, but vain, attempt to reach the North Pole. Lieutenant Anjou, at the same time, sailed from the mouth of the river Tana, reached 76° 30′ of north latitude, and passed round the group of Islands of New Siberia.

CHAPTER VII.

THE SOUTHERN LOW LANDS OF THE GREAT CONTINENT.

§ 1. Climatic character of the southern low lands. § 2. Tartar country of Manchuria; Russian colonization on the Amur. § 3. Plain of China; emigration of Chinese to British colonies. § 4. Indo-Chinese peninsula; physical features of the mountains and plains. § 5. Kingdom of Siam; productions and trading capabilities. § 6. Plains of Hindostan; Ganges valley; table-land of the Deccan; island of Ceylon. § 7. The Punjab. § 8. The great Indian desert. § 9. Arabian peninsula. § 10. Syria; mountains of Lebanon; character of the valleys and plains; the Jordan valley; the Dead Sea, its depression below the level of the Mediterranean.

§ 1. THE low lands to the south of the great mountain girdle of the old continent are much broken by its offsets, by separate groups of mountains, and still more by the deep indentations of bays and large seas. Situate in lower latitudes, and sheltered by mountains from the cutting Siberian winds, these plains are of a more tropical character than those to the N.; but they are strikingly contrasted in their different parts—either rich in all the exuberance that heat, moisture, and soil can produce, or covered by wastes of bare sand—in the most advanced state of cultivation, or in the wildest garb of nature.

The barren parts of the low lands lying between the eastern shores of China and the Indus bear a small proportion to the riches of a soil vivified by tropical warmth and watered by the periodical inundations of the mighty rivers that burst from the icy regions of Tibet and the Himalaya. On the contrary, the favoured regions in that part of the low lands lying between the Persian Gulf, the Euphrates, and the Atlas mountains, are small when compared with the immense expanse of the Arabian and African deserts scorched by a tropical sun. The blessing of a mountain-zone, pouring out its everlasting treasures of moisture, the life-blood of the soil, is nowhere more strikingly exhibited than in the contrast formed by these two regions of the globe.

§ 2. The Tartar country of Manchuria, watered by the southern tributaries of the Amur, is a varied region of wooded mountains and fertile river valleys, bounded on the W. by the moving sands of the Gobi desert.

The Russians, by gradual encroachments, were virtually in possession of this country before the late Chinese war; but when the allied English and French armies were before Pekin, the Russian minister took that favourable moment to offer his mediation, and in January, 1861, the district of the Amur (Amurskaya) was ceded to Russia by treaty, besides an extensive region along the coast to the S., bounded, on the W., by the Usuri, and on the S. by the river Tumen. By this cession Russia obtained a harbour (Possiet Bay), in lat. 42° 30′, in the sea of Japan, which is open to vessels nearly all the year round, and thus possesses great advantage over Nicolaievsk at the mouth of the Amur, which is closed by ice for five months in the year. A little to the N. of Possiet Harbour is Guerin Gulf, from which, by means of the Suifun and Lefu rivers there is water communication (with a portage of only a few miles) from these southern possessions to the Usuri river, which latter is navigable by steam-vessels nearly its whole length into the Amur. In this extensive country there are now 50,000 Russian colonists, and the whole population amounts to 74,000, spread over an area of 361,000 square miles. Near the coast stretches the range of the Sikhota Alin mountains, and the country possesses forests of valuable timber; but there are areas capable of feeding thousands of cattle, and of producing European grains to an unlimited extent. In the N., the mountains of the upper Amur abound in fine forests of oak, and are rich in gold, silver, and iron. Gold is found in all the tributaries of the Amur that have their sources in these mountains; but mining operations are limited to about four months, on account of the severity of the climate.

The Kirghis occupy a region of central Asia lying between Siberia and the northern provinces of China. It consists of vast steppes or plains, of which the sandy desert of the Great Gobi is the most extensive. They are luxuriant with grass and wild flowers for a few weeks in spring, when they are covered with innumerable groups of herds and flocks, which, although numbered by tens of thousands, appear only like spots on these all but boundless plains. In summer, whirlwinds sweep over the withered grass of this burning waste, and clouds of dust suffocate both man and beast; in winter, icy gales of irresistible fury blind with snow and freeze to death. Then the inhabitants take shelter with their flocks and herds in villages, or groups of dwellings something between a hut and a tent. They are the descendants of a race of conquerors; many of their chiefs trace their descent from Tamerlane, others from Genghis Khan; they are dignified, brave, and daring horsemen.

Such are the people that the Russians are now bringing into subjection, and have surrounded by fortified settlements, in order to add to the warlike population of the empire some hundred thousand horsemen whose military spirit and power of endurance are probably unequalled. They have already got possession of a large territory containing silver-mines of immense value in exchange for some gaudy trifling ornaments. Thus within a few years Russia has added to her enormous empire a territory equal in extent to France and Italy, rich beyond expression in the precious metals, iron, and coal. Already the foundries furnish the Russian steam navy in the North Pacific with guns and machinery, and they expect in a short time to supersede the British manufactures in all kinds of cutlery and muskets. The Russians will probably extend their newly acquired province indefinitely, for the government sends travellers and engineers in all directions; and such is the activity and skill with which that people improve their advantages, that it will require all the enterprise of our merchants, and the superior quality of their goods, as well as of the other European nations, to prevent Russia from obtaining the entire and exclusive commerce of Eastern Asia.[1]

In the Corea there are cultivated plains at the base of its central mountain range.

§ 3. China is the most productive country on the face of the earth; an alluvial plain of 210,000 square miles, formed by one of the most extensive river-systems in the old world, occupies its eastern part. This plain, seven times the size of Lombardy, is no less fertile, and well irrigated by canals. The Great Canal traverses the eastern part of the plain for 700 miles, of which 500 are in a straight line of considerable breadth, with a current in the greater part of its course. Most of the plain is laid out in rice and garden grounds, the whole cultivated with the spade. The tea-plant grows on low hills between the 30th and 32nd parallels of N. latitude, offsets from the Pe-ling chain. The cold in winter is much greater than in corresponding latitudes in Europe, and the heat in summer is proportionally excessive.

Notwithstanding the great fertility of China, and the extent of arable land, the people are always pressed for the means of subsistence, and they never were more so than now when the population amounts to 412,000,000; hence emigration is going on to an unprecedented amount to Australia, California, and even the Antilles. Queen Victoria has at present at Hong-Kong, in her Malayan colonies, and in Australia, more than a quarter of a million of Chinese subjects. This singular people, more laborious and ingenious than the most civilized of the Asiatic nations, is so much addicted to commercial intercourse with strangers that it will depend upon ourselves to improve it to the best advantage. The Russians have had for many years a religious establishment at Pekin, but of late there have been attached to it men of science, miners, geologists, and astronomers, by whose observations it appears that China abounds in palæozoic rocks with many ores and metals, vast and rich coal-fields, and, with a most productive soil, forms a wondrous mine of wealth, which, when opened out to Europeans, may operate greater changes in our international relations than all the gold of California, Australia, or British Columbia.[1]

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[1] 'Quarterly Review,' July, 1861.

§ 4. The Indo-Chinese peninsula, lying between China and the Brahmapootra river, has an area of 77,700 square miles, and projects 1300 miles into the ocean. Several parallel chains of great length detach themselves from the eastern extremity of the Himalaya, and form a number of deep valleys through which flow the upper waters of the great rivers of this region. They extend in a southerly, but diverging, direction, and spread like the spokes of a fan through the Indo-Chinese peninsula, leaving large and fertile countries between them. The Birmano-Siamese chain is the most extensive, reaching to Cape Romania at the extremity of the Malay peninsula, the most southerly point of the Asiatic continent, from whence it may be traced through the island of Sumatra, parallel to the coast, and also in the islands of Banca and Billiton, where it terminates.

Another range, called the Laos-Siamese chain, forms the eastern boundary of the kingdom of Siam, and the Annamatic chain, from the same origin, separates the empire of Annam from Tonquin and Cochin China.

These slightly diverging lines of mountains yield gold, ores of silver and tin, and precious stones, as rubies and sapphires. Mountains in low latitudes have nothing of the severe character of those in less favoured climes. Magnificent forests reach their summits; trees yielding spices, dyes of brilliant tints, medicinal and odoriferous plants, clothe their declivities; and in the low grounds the fruits of India and China grow in perfection in a soil which yields three crops of grain in the year. The plains lying between these mountains are very extensive. The Birman empire alone, which occupies the valley of the Irrawady, is said to be as large as France, and not less fertile, especially its southern part, which is the granary of the empire. Magnificent rivers intersect the alluvial plains, whose soil they have brought down from the table-land of Tibet, and still continue to deposit in great quantities in the deltas at their mouths,

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[1] Address by Sir Roderick I. Murchison, President of the Royal Geographical Society.

The base of this plateau, and a part of the Deccan, is granite, the rest one vast sheet of basalt. Though possessing the diamond-mines of Golconda, the true riches of the country consist in its vegetable mould, which in Mysore is 100 feet thick, an inexhaustible source of fertility. The sea-coasts on the two sides of the peninsula are essentially different; that of Malabar on the western side is rocky, but in many parts well cultivated, and its mountains covered with forests form a continuous wall of very simple structure, 510 miles long, and rather more than 3000 feet high. On the coast of Coromandel the mountains are bare, lower, frequently interrupted, and the wide maritime plains are generally parched.

The island of Ceylon, nearly equal in extent to Ireland, is almost joined to the southern extremity of the peninsula by sandbanks and small islands, between which the water is only six feet deep at low water spring-tides. The Sanscrit name of the "Resplendent" may convey some idea of this island, rich and fertile in soil, adorned by lofty mountains, numerous streams, and primeval forests; in addition to which it is rich in precious stones, and has fisheries of the pearl oyster on its coast.

§ 7. The Asiatic low lands are continued westward from the Indian peninsula by the Punjab and the great Indian desert. "The Punjab, or country of the five rivers," lies at the base of the Western Himalaya. Its most northern part consists of fertile terraces highly cultivated, and valleys at the foot of the mountains. It is very productive in the plain within the limits of the periodical inundations of the rivers, and where it is watered by canals; in other parts it is pastoral. The kingdom of Lahore occupies the chief part of the Punjab, and the city of that name near the Ravee, the ancient Hydraotes, once the rival of Delhi, lies on the high road from Persia to India, and was made the capital of the kingdom by the founder of the Sikh dynasty, Runjeet Sing. The lower valley of the Indus throughout partakes of the character of the Punjab; it is fertile only where it is within reach of water; much of it consists of a delta, which is occupied by rice-grounds; the rest is pasture, or sterile salt mashes.

§ 8. South of the Punjab, and between the plains of Hindostan and the left bank of the Indus, lies the great Indian desert, which is about 400 miles broad, and becomes more and more arid as it approaches the river. It consists of a hard clay, covered with shifting sand, driven into high mounds by the wind, with some parts that are verdant after the rains. In the province of Cutch, S. of the desert, a space of 7000 square miles, known as the Runn of Cutch, is alternately a sandy salt-plain, level as a bowling-green, and an inland sea. In April the waves of the sea are driven over it by the prevailing winds, leaving only a few grassy eminences, the resort of the wild ass. The desert of Mekran, an equally barren tract, extends along the Gulf of Oman from the mouths of the Indus to the Persian Gulf: In some places, however, it produces the Indian palm and the aromatic shrubs of Arabia Felix. It was the line followed by Alexander the Great returning with his army from India.

The scathed shores of the Arabian Gulf, where not a blade of grass freshens the arid sands, and the uncultivated valleys of the Euphrates and Tigris, separate Asia from Arabia and northern Africa, the most desert regions in the old world.

§ 9. The peninsula of Arabia, divided into two parts by the Tropic of Cancer, is about four times the size of France. There are no rivers, and few streams or springs nourish the thirsty land, whose barren sands are scorched by a fierce sun. The central part is a table-land of moderate height, which, however, is said to have an elevation of 8000 feet in the southern province of Haudramaut. To the S. of the tropic it is an almost interminable ocean of drifting sand, wafted in clouds by the gale, and dreaded even by the wandering Bedouin. At wide intervals, long narrow depressions cheer the eye with brushwood and verdure. More to the N., mountains and hills cross the peninsula from S.E. to N.W., enclosing cultivated and fine pastoral valleys adorned by groves of the date-palm and aromatic shrubs. Mr. Gifford Palgrave in the years 1862-63, crossed Arabia from a point two days' journey to the N. of Akaba to El Khatif on the shores of the Persian Gulf. In this journey, a waterless desert was first crossed, which reaches to the frontiers of the kingdom of Jebel Shomer. This independent principality lies between 26° 30′ and 32° N.; and between 33° 40′ and 44° E. Two-thirds of this area is desert; but there are here and there fertile spots, such as Jaûf, where lovely villages nestle under palm trees, and such as the approaches to Haîl, the capital, lying among fertile valleys, many of which run from N.E. to S.W. The kingdom of the Wahabees, whose sovereign is known as the Sultan of Nejed, lies S.E. of the kingdom of Jebel Shomer, and extends over 10° of latitude and 7° of longitude, being bounded on the W. by one of the pilgrim routes to Medina, and on the E. by the Persian Gulf. The capital is Riadh, and besides this there are many fortified towns standing in the midst of widely extended gardens and plantations. The broad and fertile plains of Kasim intervene between Jebel Shomer and the Nejed territory, the latter of which is elevated, and in it is found the plateau of Jebel Toweyk, having an elevation of 2000 feet. This plateau has much pasture-land, on which countless herds of camels and sheep graze. It is intersected by a net-work of valleys full of life and cultivation. Eastward of Riadh fine plains were found; but before reaching the fertile coast-

The base of this plateau, and a part of the Deccan, is granite, the rest one vast sheet of basalt. Though possessing the diamond-mines of Golconda, the true riches of the country consist in its vegetable mould, which in Mysore is 100 feet thick, an inexhaustible source of fertility. The sea-coasts on the two sides of the peninsula are essentially different; that of Malabar on the western side is rocky, but in many parts well cultivated, and its mountains covered with forests form a continuous wall of very simple structure, 510 miles long, and rather more than 3000 feet high. On the coast of Coromandel the mountains are bare, lower, frequently interrupted, and the wide maritime plains are generally parched.

The island of Ceylon, nearly equal in extent to Ireland, is almost joined to the southern extremity of the peninsula by sandbanks and small islands, between which the water is only six feet deep at low water spring-tides. The Sanscrit name of the "Resplendent" may convey some idea of this island, rich and fertile in soil, adorned by lofty mountains, numerous streams, and primeval forests; in addition to which it is rich in precious stones, and has fisheries of the pearl oyster on its coast.

§ 7. The Asiatic low lands are continued westward from the Indian peninsula by the Punjab and the great Indian desert. "The Punjab, or country of the five rivers," lies at the base of the Western Himalaya. Its most northern part consists of fertile terraces highly cultivated, and valleys at the foot of the mountains. It is very productive in the plain within the limits of the periodical inundations of the rivers, and where it is watered by canals; in other parts it is pastoral. The kingdom of Lahore occupies the chief part of the Punjab, and the city of that name near the Ravee, the ancient Hydraotes, once the rival of Delhi, lies on the high road from Persia to India, and was made the capital of the kingdom by the founder of the Sikh dynasty, Runjeet Sing. The lower valley of the Indus throughout partakes of the character of the Punjab; it is fertile only where it is within reach of water; much of it consists of a delta, which is occupied by rice-grounds; the rest is pasture, or sterile salt mashes.

§ 8. South of the Punjab, and between the plains of Hindostan and the left bank of the Indus, lies the great Indian desert, which is about 400 miles broad, and becomes more and more arid as it approaches the river. It consists of a hard clay, covered with shifting sand, driven into high mounds by the wind, with some parts that are verdant after the rains. In the province of Cutch, S. of the desert, a space of 7000 square miles, known as the Runn of Cutch, is alternately a sandy salt-plain, level as a bowling-green, and an inland sea. In April the waves of the sea are driven over it by the prevailing winds, leaving only a few grassy eminences, the resort of the wild ass. The desert of Mekran, an equally barren tract, extends along the Gulf of Oman from the mouths of the Indus to the Persian Gulf: In some places, however, it produces the Indian palm and the aromatic shrubs of Arabia Felix. It was the line followed by Alexander the Great returning with his army from India.

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The south-eastern coast is scarcely known, except towards the provinces of Haudramaut and Yemen, or Arabia Felix, where ranges of mountains, some above 5000 feet high, line the coast, and in many places project into the ocean, sometimes forming excellent harbours, as that of Aden, which is protected by projecting rocks. In the intervals there are towns and villages, cotton-plantations, date-groves, and cultivated ground.

On the northern side of these granite ranges, where the table-land is 8000 feet above the sea, and along the edge of the desert of El Aklaj in Haudramaut, there is a tract of sand so loose and so very fine, that a plummet was sunk in it by Baron Wrede to the depth of 360 feet without reaching the bottom. There is a tradition in the country that the Sabæan army of King Suffi perished in attempting to cross this desert. Arabia Felix, which merits its name, is the only part of that country with permanent streams, though they are small. Here also the mountains and fertile regions run far inland, producing grain, pasture, coffee, odoriferous plants, and gums. High cliffs line the shores of the Indian Ocean and the Strait of Bab-el-man-deb — "the Gate of Tears." The fertile country is continued a considerable way along the coast of the Red Sea, but the character of barrenness is resumed by degrees, till at length the hills and intervening terraces, on which Mecca and Medina, the holy cities of the Mohammedans, stand, are sterile wastes wherever springs do not water them. The blast of the desert, loaded with burning sand, sweeps over these parched regions. Mountains skirt the table-land to the N.; and the peninsula, between the Gulfs of Akaba and Suez on the Red Sea, is filled by the mountain-group of Sinai and Horeb. Jebel Houra, Mount Horeb, on which Moses received the Ten Commandments, is 8593 feet high, surrounded by still higher peaks, which are covered with snow in winter. The group of Sinai abounds in springs and verdure. At its northern extremity lies the desert of El-Tìh, 70 miles long and 30 broad, in which the Israelites wandered 40 years. It is covered with long ranges of high rocks, of most repulsive aspect, rent into deep clefts only a few feet wide, hemmed in by walls of rock sometimes 1000 feet high, like the deserted streets of a Cyclopean town. The journey from Sinai to Akaba, by the Wady-el-Ain, or Valley of the Spring, is magnificent, and the site of Petra itself is a tremendous confusion of black and brown mountains. It is a considerable basin closed in by rocks, with chasms and defiles in the precipices. The main street is two miles long, and not more than from 10 to 30 feet wide, enclosed between perpendicular rocks from 100 to 700 feet high, which so nearly meet as to leave only a strip of sky. A stream runs through the street which must once have been a considerable torrent, and the precipitous rocks are excavated into thousands of caverns once inhabited—into conduits, cisterns, flights of steps, theatres, temples, and sepulchres, forming altogether one of the most wonderful remains of antiquity. The whole of Arabia Petrea, the Edom of sacred writers, presents a scene of appalling desolation, completely fulfilling the denunciation of prophecy.

§ 10. A sandy desert, crossed by low limestone ridges, separates the table-land of Arabia from the habitable part of Syria, which the mountains of Lebanon divide into two narrow plains. These mountains may also be considered offsets from the Taurus chain; at least, they are connected with it by the wooded range of Gawoor, the ancient Amanus, impassable except by two defiles, celebrated in history as the Amanic and Syrian Gates. The group of Lebanon begins with the Jebel Okrab (Mount Cassius), which rises abruptly from the sea in a single peak to the height of 7000 feet, near the mouth of the Orontes. From thence the chain runs south at a distance of about 20 miles from the shores of the Mediterranean, in a continuous line of peaks to the sources of the Jordan, where it splits into two nearly parallel branches, enclosing the upper valley of the river Litany, the ancient Leontes, and the wide and fertile plain of Buka, the ancient Cœlo-Syria, in which are the ruins of Baalbek.

The Lebanon branch, the western range, contains the high peaks of Dhor-el-Kodib and Jebel Sunnin. South of the latter of these mountains the range sinks down, expanding in breadth as it diminishes in height. It forms by its spurs and their continuations the hill country of Galilee, that of Samaria, and the S. country of Judea, which gradually fades away into the Desert of Paran, the modern El Tìh. Plains and valleys are enclosed among those hills, and border the Mediterranean coast. The Anti-Libanus, which commences N.E. of Baalbek, attains its greatest height at Mount

Hermon, or Jebel Sheikh, 9800 feet high, near the highest sources of the Jordan, from whence it runs along the left bank of that river, forming the trans-Jordanic range, which everywhere bounds the eastern horizon to the traveller in Western Palestine, the long, straight line of the mountains of Ajlun, Gilead, and Moab.

To the E. and S.E. of Hermon extends a vast rugged region comparatively unmarked by any high peaks, but seamed and furrowed by endless hidden ravines, cracks in the molten sea of lava which has once been poured over the whole country, and which has cooled down a very sea of black rock. This district, the Argob of the Old Testament, the Trachonitis of the New, is now called the Lejah; and in its cracks and fissures still maintains a considerable population.

The tops of all the mountains, from Scanderoon to Jerusalem, are covered with snow in winter; it is permanent on Lebanon only, whose highest peak, Dhor-el-Khodib, just above the famed cedar grove, attains an elevation of 10,050 feet. The precipices are terrific, the springs abundant, and the spurs of the mountains are studded with villages and convents; there are forests in the higher grounds, and lower down vineyards and gardens. Many offsets from the Libanus end in precipices on the coast between Tripoli and Beyrout, among which the scenery is very beautiful.

The valleys and plains of Syria are rich in their vegetable soil, particularly the plain of Damascus, which is brilliantly verdant, though surrounded by deserts, the barren uniformity of which is relieved on the E. by the ruined temples of Palmyra (Tadmor). The Syrian wilderness, however, is not everywhere absolutely barren. In the spring-time it is covered with a thin but vivid verdure, mixed with aromatic herbs of very short duration. When these are burnt up, the unbounded plains resume their wonted dreariness. The country, high and low, becomes more barren as we approach the Holy Land, yet even here some of the mountains —as Carmel, Bashan, and Tabor—are wooded, and many of the valleys are fertile, especially the valley of the Jordan, which has the appearance of pleasure-grounds with groves of trees and aromatic plants. The sea-coast plains are often of "surpassing richness, yielding in profusion the crops of Southern Europe, corn, millet, and abundance of fruits, with rich gardens and orchards round the cities." The greater part of Syria is now a desert compared with what it formerly was. Mussulman rule has blighted this fair region—the Land of Promise, once flowing with milk and honey.

The valley of the Jordan, called El Ghor, affords the most remarkable instance known of the depression of a considerable tract of the land below the general level of the ocean. El Ghor is not a valley merely, but a deep chink, ploughed deep down into the bowels of the earth. From the source of the river in the Anti-Lebanon the valley steadily deepens. The first pause is in the wide basin of Lake Merom, the modern Huleh, from which the valley rapidly descends to the Sea of Galilee. Leaving this lake, the river runs in a tortuous course through the valley to the great depression of the Dead Sea, 1292 feet below the level of the Mediterranean, the deepest depression on the earth's surface. The lower terraces of the valley, which constitute the edge of the Ghor, or "Plain of the Jordan" of the Jews, form a narrow trench, rarely more than two miles wide, while the upper terraces reach back for several miles to the enclosing hills. Southward of the Dead Sea, this deep trench continues in the Arabah, but gradually rises, until a little south of Petra the watershed of the Dead Sea and the Red Sea is found at a height of 787 feet above the sea-level, to which the valley of Akaba thence descends.

The natural products of the Jordan valley are unique. It is a tropical oasis, sunk in the temperate zone, and overhung by an Alpine Hermon. Acres of papyrus are found in the marshes of Lake Merom; the plain of Gennesaret, on the western shore of the Sea of Galilee, also produces papyrus, and the jujube (a tropical tree). Palms and oleanders wave in the valley S. of Galilee; and round the Dead Sea, in five oases, are found, nourished by copious springs, many of the products of the torrid zone. Indigo and henna flourish, and melons ripen in a winter during which the thermometer ranges between 60° and 80° Fahr. The birds and insects, also, are either peculiar to the district, or are such as are found in Nubia, Abyssinia, India, and Equatorial Africa. The Jordan valley is an actual geological line, the formations differing on each side. The Dead Sea has been shown by M. Lartet to have had no connection with the Red Sea since the continent assumed its present form. Many hot springs and sulphur springs are found in the basin of the Dead Sea; but Jebel Usdum, a mass of rock salt, seven miles long, a mile and a half wide, and several hundred feet high, is the most interesting phenomenon about the lake. M. Lartet considers that the Dead Sea has never been anything but a reservoir for the water brought in by the various streams, deriving its saltness partly from the salt rocks near it and partly as a result of incessant evaporation.[1]

There is evidence that the country round the northern end of the Red Sea has been raised above its former level within the last 3000 years. Caverns are found in the cliffs on the Red Sea, and in those more inland on the Arabian coast, and the whole desert from Suez to Cairo is covered with abundance of shells, similar to those now living in the Red Sea, which was probably joined to the Mediterranean at a very recent period.

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[1] The Rev. H. B. Tristram's chapters on the Physical Geography of Palestine in his 'Natural History of the Bible.'

It appears from the surveys which were executed with a view to unite the two seas by a canal, that they are on the same level; that for 13½ miles, from high-water mark at Suez to the Bitter Lakes, the land is nearly level, rising from 3 to 12 feet only above the highest tide. Here a depression of 16 feet begins, which extends for 27 miles. The surface of the Bitter Lakes, which appear to be fragments of the Red Sea or Mediterranean, lowered by evaporation, is 54 feet below the level of the latter. From thence to the Mediterranean the ground is low and marshy, with numerous lagoons of salt water. The shortest distance from the Red Sea to the Mediterranean is 75 miles. The canal which, through the energy of M. de Lesseps, has been made from sea to sea was opened in 1869. It cuts through the low sandy isthmus to the E. of the delta of the Nile, and passes from Lake Menzaleh, the most easterly of the lagoons formed round the delta of the Nile, to the head of the Gulf of Suez. It passes through the shallow lake Menzaleh, the small lakes Abuballah and Timsah, and a fourth formed in the basin of the Bitter Lakes, by water let into it from the Mediterranean, which has raised their level. The length of the canal is 100 English miles, and its depth 26 feet; it has no locks. The general width is 246 feet at the base of the banks, and 72 feet at the bottom of the canal. A new town, called Port Said, has been established at the northern end of the canal, and another, Ismailia, on Lake Timsah. The Natron lakes on the Libyan desert, W. from the delta of the Nile, are probably also fragments of an inland sea.[1]

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[1] See the works of Dr. Buist, Mr. Glyn, and the Survey published by M. de Lesseps. Miss Fanny Corbaux was one of the first who drew attention to this subject.

CHAPTER VIII.

AFRICA.

§ 1. Configuration of the African continent. § 2. South African table-land. § 3. Cape of Good Hope and eastern coast; geological formation; arid plains; inland parallel ranges; coast of Natal; island of Madagascar. § 4. West coast of South Africa; Cape Negro; maritime plains; delta of the Niger. § 5. Table-land north of the Cape; little known of this region till lately; Dr. Livingstone's discoveries. § 6. Tropical Africa; researches of Captains Burton and Speke. § 7. Abyssinia; physical characteristics; geological structure. § 8. Senegambia. § 9. Low lands and deserts; lake Tchad; Sahara desert; Nubian and Libyan deserts; the oases. § 10. Geological notice.

§ 1. THE continent of Africa is 4330 geographical miles long from Cape Agulhas, E. of the Cape of Good Hope, to Cape Bianco, near Bizerta, its northern extremity, and 4000 broad, between Cape Guardafuï, on the Indian Ocean, and Cape Verd, on the Atlantic; but from the irregularity of its figure it has an area of only twelve millions of square miles. It is divided in two by the equator, consequently the greater part lies under a tropical sun. The high and low lands of this portion of the old continent are so distinctly separated that, with the exception of the mountainous territory of the Atlas and the small table-land of Barca, it may be said to consist of two parts only, a high country and a low.

§ 2. An extensive, though not very elevated, table-land occupies all Southern Africa, and extends six or seven degrees N. of the equator. On the N.W. it terminates in the high land of Senegambia, and on the N.E. in that of Abyssinia, both of which project farther to the N. than the central edge of the plateau, which has not yet been explored. On the E. and W. the table-land is bounded either by mountain-chains or high ridges of various kinds and elevations, which divide it from the narrow coast plains and the deltas of rivers which terminate in the Indian and Atlantic Oceans; and on the S. the table-land shelves down to the sea in narrow parallel terraces.

§ 3. In its southern extremity at the Cape of Good Hope the African continent is about 700 miles broad, and ends in three narrow parallel ridges of mountains, the last of which is the highest, and abuts on the table-land. All are cleft by precipitous deep ravines, through which winter torrents flow to the ocean. The longitudinal valleys, or karroos, that separate them, are tiers, or steps, by which the plateau dips to the maritime plains. The descent is rapid, as both these plains and the mountain-ranges are very narrow. On the western side the mountains form a high group, and end in steep promontories on the coast, where Table-Mountain, at Cape Town, 3582 feet high, forms a conspicuous landmark for mariners.

Granite rocks, which are the base of this part of southern Africa, rise to a considerable height in many places, and are generally surmounted by vast horizontal beds of sandstone, which give that character of flatness peculiar to the summits of many of the Cape mountains.

The karroos are arid deserts in the dry season, but soon after the setting in of the rains they are covered with verdure and a splendid flora. The maritime plains partake of the same temporary aridity, though a large portion is rich in cereal productions, vineyards, fruits, and pasture.

The most inland of the ranges parallel to the Indian Ocean is 10,000 feet high, and it rises about the 27th meridian, in a truly Alpine and continuous chain—the Quatlamba mountains, which sink into a broad ridge not more than 4000 feet above the level of the sea before crossing the Zambesi river at the beginning of its delta, about 300 miles from the ocean. The surface of the ridge is a fine undulating country, covered with short grass like a lawn, and yielding excellent wheat and other cereals, with various roots in great abundance. From the head of the delta the ridge which borders the table-land divides into several branches. One, known as the Lupata chain, runs at the distance of 160 miles inland along the coast of Sofala; others bend west, while the central and principal chain runs northward, encircling Lake Nyassa at a considerable distance from the coast. It is of moderate altitude in the country of Unyamwezi, but rises to a great height between the third and fourth degrees of S. latitude, where Kilimanjaro (20,065 feet) rises to the zone of eternal snow, and other peaks seem to connect the range with the high lands of Abyssinia.

At Natal the coast land slopes upward from the sea to the summit of the range, here called the Drakenberg, and the climate and vegetation of the valleys, exposed to the warm and moist airs of the Indian Ocean are subtropical. The Zambesi and other streams from the table-land refresh the plains on the Mozambique Channel. Opposite Zanzibar, though some parts are marshy and covered with mangroves, groves of palm-trees adorn the plains, which yield prodigious quantities of grain, and noble forests cover the mountains;

but from 4° N. latitude to Cape Guardafuï is a continued desert, the hot and dry region inhabited by the jealous and ferocious Somāli. There is also a barren tract at the southern end of the Lupata chain, and along the southern tributaries of the Zambesi, where gold is found in masses and grains on the surface and in the watercourses, which tempted the Portuguese to form settlements on these unwholesome coasts. Here were situated Maniça, and the country of Monomotapa, depicted on old maps, and the district, together with the seaport Sofala, is suggested by some writers to be the Ophir of Scripture.

The island of Madagascar, with its magnificent range of mountains, encircled by a belt of primeval forests, is parallel to the African coast, and only separated from it by the Mozambique Channel, 250 miles broad; its organic productions as a whole differ very greatly from those of Africa, showing that there has been no connexion between the two lands since they were stocked by their present forms of life.

§ 4. The contrast between the eastern and western coasts of South Africa is very striking. The escarped bold mountains round the Cape of Good Hope, and its rocky coast, which extends a short way along the Atlantic to the N., are succeeded by ranges of sandstone of small elevation, which separate the internal sandy desert from the sandy shore which, with the exception of Walvisch Bay, is equally parched. The terraced slope of the Atlantic coast for 900 miles between the Orange River and Cape Negro has not a drop of fresh water.

At Cape Negro terraces separated by long level tracts begin and make a semicircular bend into the interior, leaving plains along the coast 140 miles broad, from whence the highest terrace appears like a chain of mountains, because it dips for 2000 feet towards them. It has a broad flat top, spreading into fine grassy plains, on which are found Cape-heaths, rhododendrons, and other Alpine plants, quite different from the tropical vegetation on the maritime coast on one side, or on the table-land on the other. The high terraces are continued to the country of Colbongos, the most elevated land on the coast, where a magnificent group of mountains, covered to their tops with large timber, lie not far inland and N. of these. King William's mountains form the eastern border of this side of the table-land.

The maritime plains on the Atlantic along this long line of high country have for the most part a tropical vegetation. In Benguela the plains are healthy and cultivated; farther N. there are monotonous grassy savannahs, and forests of gigantic trees. The ground, in many places saturated with water, bears a tangled crop of mangroves and tall reeds which even cover the shoals along the coast; hot pestilential vapours hang over them, never dissipated by a breeze.

Such are the low lands of the Fernan Vaz River and the Gaboon, and farther N. the plains of Biafra and Benin, and the delta of the Niger.

The Angel of Death, brooding over these regions in noisome exhalations, guards the interior of that country from the aggressions of the European, and has hitherto baffled his attempts to form settlements on the banks of this magnificent river.

Many portions of N. Guinea are so fertile that they might vie with the valley of the Nile in cereal riches, besides various other productions; and, though the heat is great, the climate is not very unhealthy.

Such are the mountain-chains and maritime plains that surround the table-land of South Africa on three sides.

§ 5. In the beginning of the present century the table-land N. of the Cape of Good Hope was almost an unknown region. Mr. Somerville and Mr. Truter were the first white men whom the inhabitants of Litakoo had seen. Of an expedition that followed their track a few years after no one returned. Since that time it has been frequently explored both by the missionaries and other travellers, and now the central portion, as far as the Victoria Falls of the Zambesi, is tolerably well known.

Immediately N. of the Cape mountains the table-land is 600 feet above the level of the sea, and, for a comparatively small distance, it is cultivated and pastoral, and in all probability it is equally so at the foot of the Quatlamba chain, for there are forests and rich pasture lands in the Bushmen's country, at least for part of the year. With these exceptions the Kalahari Desert spreads over the table-land to the 20th degree of S. latitude. The Gareep, or Orange River, with its tributaries, which flow across the desert, may be more aptly said to drain than to irrigate this arid country. Many of the tributaries are only the channels through which torrents from the periodical rains are carried to the main stream, and are destitute of water during many months in the year. "The Dry River," the name of one of these, is no misnomer in that country. However, moisture is not wanting, for the margin of the streams is usually adorned with mimosas, and the sandy deserts in some places have furnished treasures to the botanist after the rains, but in general the camel's-thorn and other products of the African desert are the only vegetation, where there is any vegetation at all. On the W. it is bounded by the pastoral and even agricultural countries of the Great Namaqua and Damaras, but these are penetrated in many places by the desert, even to the sandy shores.

Nothing was known of the interior of the table-land N. of the Kalahari Desert till, in 1802, intelligent native merchants crossed from Loanda on the Atlantic to Zanzibar on the Mozambique coast, and from their account Europeans first had an idea of the nature of the country, its productions, and the state of its inhabitants; but it is to the missionaries that we owe our real knowledge of the interior of South Africa. Among these Dr. Livingstone is pre-eminent. Of high scientific acquirements and unconquerable zeal in the great cause, he traversed the table-land from sea to sea, performing in all a journey of 11,000 miles, in order to establish missions for the conversion and instruction of the natives. Although that was his principal object, yet during the journey, amidst innumerable difficulties and thirty-two attacks of fever, he made astronomical observations to ascertain the latitude and longitude of the most remarkable places he visited, from which a beautiful map was constructed by Mr. Arrowsmith of tracts over most of which the foot of a white man had never passed. Dr. Livingstone set out from Kolobeng, the advanced post of the missionaries N. from the Cape of Good Hope, and, after a month's journey over 300 miles of desert, in great want of water, he came to the banks of the Zouga, a noble and exquisitely beautiful river, richly fringed with fruit-bearing and other trees, and communicating with Lake Ngami, which he first visited in 1849, and which is from 50 to 70 miles long, and 3713 feet above the level of the sea. The Zouga is the most southerly of that magnificent series of rivers discovered by Dr. Livingstone in the very centre of S. Africa, which extends from the 20th parallel of S. latitude to within ten degrees of the equator, and in longitude throughout the whole breadth of the table-land.

The country N. of Lake Ngami is a dead flat for hundreds of miles, interlaced by a perfect labyrinth of rivers with their countless tributaries and numerous entering and re-entering branches, on account of which it is called Linoka-noka, or "Rivers upon Rivers." The waters of this network of lakes and rivers, deflected in various directions by slight elevations, escape to the eastern and western oceans by passing through deep rents in the flanking ridges on each side of the plateau. In many places the meadow-lands are the pasture-grounds of the natives, covered with thousands of cattle, but in the forests both horses and cattle fall victims to the tsetsé, a poisonous fly which abounds in them. Large tracts of this country are inundated during the periodical rains, and, when the water retires, the rank vegetation and wide-spreading marshes under a tropical sun send forth exhalations nearly as fatal to man as the tsetsé is to cattle; indeed, one place is called The Fever Ponds.

The Zambesi is the main watercourse of the magnificent river system into which all the lesser systems and streams flow, many of which are great deep rivers. The natives are quite aware of its importance, since its various names of Luameji, Leeambye, and Zambesi, simply mean "The River." It makes various windings in its course from the W., especially an almost semicircular bend to the S., at the extremity of which, in 17° 57′ S. lat. and 26° 6′ E. long., it forms a magnificent cascade, to which the name "Victoria Falls" has been given; then it flows to the N. in rapids till it is joined by its tributary the Kafue, when it turns to the E. and flows generally in that direction to the Mozambique Channel, forming a delta 300 miles long. In some places the river is a mile broad, with islands covered with the richest vegetation of large trees, among which the date palm and the lofty palmyra are the most beautiful.

The productions of this country are most valuable. The Roman Catholic missionaries introduced the pine-apple, which now grows for miles along the roads in Angola; and, what is of more importance, the finest Mocha coffee, which now grows wild in the greatest abundance. Dr. Livingstone found the vine loaded with bunches of dark-purple grapes, the indigo-plant in great abundance, the sugar-cane, papyrus, a strong kind of flax, buáze, senna, and, in the woods where fever prevails, a kind of cinchona, which the natives use as a remedy against that malady. They cultivate wheat, manioc, yams, millet, rice, bananas, and vast quantities of Caffre corn. The sugar-cane has been cultivated by them from time immemorial, though they have never discovered how to make sugar from it. Elephants' tusks and bees'-wax are articles of commerce, the pioneer to the hives being the honey-bird, a species of cuckoo. The enormous quantity of wild animals shows that pasture-land in this upper region of the Zambesi must be very extensive. Dr. Livingstone fell in with troops of elephants exceeding anything hitherto described, and so tame that he was obliged to halloo to them to get out of the way; besides buffaloes, giraffees, zebras, antelopes, and wild hogs in great numbers.

The mineral riches are very considerable. The town of Teté, on the Zambesi, stands in an extensive coal-field, part of which is surrounded by a gold-producing district; and iron, of a quality equal to that of Sweden, is used by the natives for their weapons.

In 1859 Dr. Livingstone discovered the great fresh-water lake Nyassa, which extends nearly N. and S. a length of 250 miles with a width varying from 20 to 60 miles. It is not a shallow sheet of water like Lake Ngami, but is of great depth with the water blue as that of the ocean; no bottom was found in some places with a line of 40 fathoms. A range of mountains borders the lake on each side, from which descend numerous perennial streams; the prevailing winds are from the S.E., and they blow with such force, in the height of the dry season when not a cloud obscures the sky, that an ordinary sailing-boat runs hourly risk of being capsized. The northern termination of the lake is at present unknown. It lies at an altitude of 1522 feet above the sea-level, and at the southern end the surplus waters flow off by the river Shiré towards the Zambesi, the river forming a series of cataracts and rapids in its descent towards the low country. To the S.E. of this magnificent sheet of water, and separated from it by an isthmus 30 miles wide, lies Lake Shirwa, a much smaller area, lying at a much higher level than Nyassa, being 2000 feet above the sea. Between it and the Shiré is a range of uplands, the culminating peaks of which rise to an altitude of 8000 feet. In these high lands discovered by Livingstone was established the Universities' Mission under the lamented Bishop Mackenzie.

§ 6. While Dr. Livingstone was making these remarkable discoveries Captains Burton and Speke returned from a journey they made from Zanzibar into the interior of tropical Africa more to the N. They ascended the river Pangany for 120 miles through an unhealthy but rich and rather well-cultivated plain, and crossed the coast-chain of mountains about 60 miles broad. The interior, at first poor, soon became a luxuriant country, in which tobacco, cotton, and various useful plants are cultivated by a peaceful race of negroes who possess abundance of cows and goats, and know how to manufacture both iron and cotton. On proceeding into the interior the travellers discovered the Lake Tanganyika, whose position had been pretty accurately described by the natives to Dr. Livingstone. It lies between the parallels of 3° 10′ and 7° 50′ S. lat., its centre being in about 30° E. long. It abounds in good fish, and, as the tsetsé fly does not infest this part of Africa, its banks are browsed by the red oxen that are common throughout the country, and occasionally have stupendous horns. At a distance of 200 miles of very lofty mountainous country N.W. from Lake Tanganyika Captain Speke came to a great fresh-water lake called the Victoria Nyanza, between 3000 and 4000 feet above the level of the sea, which he believed to be the ultimate source of the Nile and which he afterwards revisited in company with Captain Grant. On this latter memorable expedition, the two travellers traversed the region of Equatorial Africa from Zanzibar to the upper waters of the Nile, emerging on the Mediterranean in the month of June, 1863. They skirted the western shores of the lake, but seldom sighted its waters, and then after following the stream which drained it on the N., for some portion of its course, struck across for the White Nile. They were informed by the natives that this stream entered, not far to the W., a second great lake before it re-emerged as the Nile. Regretting he was unable to visit this second lake, the Luta Nzigé, Captain Speke, on his arrival at Gondokoro, recommended Mr. (now Sir Samuel) Baker, who had come up the Nile bringing succour to the expedition, to endeavour to reach it. The advice was taken, and the result, as is now well known, was the discovery of the

Albert Nyanza, a still grander sheet of water than the Victoria, lying in a deep trough amid lofty mountains and glorious Alpine scenery. The Albert Nyanza lies at an altitude of about 2550 feet above the sea-level, or nearly 1000 feet lower than the Victoria Lake, the slope of the country being from S.E. to N.W.

§ 7. The vast Alpine promontory of Abyssinia or Ethiopia,[1] 700 miles wide, projects from the table-land for 300 miles into the low lands of North Africa. It dips to a low swampy region on the N., to the plains of Senaar and Kordofan on the W., and on the E. sinks abruptly to the coast at a short distance from the shores of the Red Sea. It is there from 8000 to 9000 feet high on the plateau of Tigre, but declines to the westward, so that in the 15th parallel of N. lat. the eastern slope of the table-land towards the Red Sea is nearly twenty times greater than the counter-slope towards the Nile; the edge of the latter, however, is from 3000 to 4004 feet above the plains.[2] The table-land of Abyssinia is a succession of plains, diversified by higher insulated mountain-masses, which in the S. attain an absolute altitude of from 11,000 to 13,500 feet.[3] These plains are intersected by the extremely deep ravines in which flow the numerous streams which form the tributaries of the Nile on the one hand, and the Hawásh and its affluents, which flow towards the Indian Ocean, to be lost in a swamp, or in the salt-plains, on the other. The recent military expedition to Abyssinia discovered in the broken, low coast land the Ragolay and its tributaries which drain the eastern side of the Abyssinian watershed from Senafe to Atsbi, a distance of 70 geographical miles. The Ragolay is a perennial stream; but in flowing towards the sea, it sinks into a depression 193 feet below the sea-level, and its waters are finally dissipated by heat and by absorption in the sand. The edge of the table-land on the W. is steep; the streams run to the low lands through valleys from 3000 to 4000 feet deep. These gorges have often wild and extremely picturesque scenery. They contain in their depths a tropical vegetation, while towards their upper portions, the flora of Italy and of England find representatives. A traveller in ascending them might imagine that he is crossing a mountain-range, whereas, on coming to the top, he finds himself on a high plain. This elevated country has lakes, swamps, verdant meadows, and cultivated land, producing various kinds of grain, and occasionally coffee. The plain of Dembia, the granary of the country, enjoys perpetual spring. M. A. d'Abbadie and Dr. Beke travelled to within 8° of the equator, and, by their account, the country S. of Abyssinia appears to be similar to that of Shoa and Gojam—extensive undulating plains, with occasional mountain-masses, and traversed by numerous streams; wide tracts must be 7000 or 8000 feet high, as they only produce barley: the country towards Kaffa and the sources of the Gojeb is still higher, and in some parts desert; but the caravan-road between Wallega and Kaffa passes through a vast forest impervious to the rays of the sun, which, according to the accounts of the merchants, is not seen for four or five days successively; and W. of the Did-ësa there are immense grassy plains, the elephant-hunting grounds of the Galla tribes.

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[1] The name of Ethiopia is still used by the Abyssinians, as stated by M. A. d'Abbadie, who resided many years among them, as including Abyssinia proper, the Bija country as far as Sawakin, the Afar (Aidal of our maps), the Somaly, Gurage, and Galla countries. The word Abyssinia, according to the same traveller, is better employed in the Arab sense for those populations, chiefly Christian, which have lost all idea of tribe.

[2] Estimated from N.E. to S.W., the proportion of the two slopes of the Abyssinian table-land is as 12·6 to 1.

[3] The highest inhabited village visited by M. d'Abbadie was that of Arquiaze, in the province of Simën, 12,450 feet above the sea.

The expedition sent from England for the relief of the British prisoners detained by King Theodore was accompanied by scientific men who carefully examined the geography of the country through which the force passed. The Wadela and Dalanta plateaux, which were crossed on the road to Magdala, have an elevation of over 9000 feet; and it is evident, says Mr. Clements Markham, that they were once a single mass of columnar basalt. The river Jitta has in the course of ages cut a deep ravine of 3500 feet, which has almost perpendicular sides between these plateaux. The Beshilo ravine, still deeper than that of the Jitta, bounds the Dalanta plateau on the S.; and the Magdala system, or knot of mountains, lies with others still farther to the S. The country here consists of mountain masses, many with perpendicular sides, only broken by terraces, and with flat summits on which forts have been constructed. These mountains are separated by deep ravines and gorges. Magdala itself is a mass of columnar basalt, with scarped perpendicular sides, and with a waterless plateau on the top, which is about two miles long by half a mile across; it is 9050 feet above the level of the sea. The lofty ridges and deep ravines of the country round Magdala are very grand, and overtopping them all rises the straight basaltic wall of Dalanta.

The geological structure of Ethiopia is somewhat similar to that of the Cape of Good Hope, the base being granite and the superstructure sandstone, occasionally limestone, schist, and breccia. The granite comes to the surface in the lower parts of Abyssinia, but sandstone predominates in the upper, and assumes a tabular form, often lying on the tops of the mountains in enormous flat masses, only accessible by steps cut in the rocks or by ladders: such insulated spots are used as state prisons. Large tracts of ancient volcanic rocks occur, especially in Shoa. Traps rocks also abound in Simën. Many of the hill forts in Abyssinia are basaltic.

§ 8. Senegambia, the appendage to the western extremity of the table-land, also projects far into the low lands, and is the watershed whence the streams flow on one side to the plains of Soudan, where they join the Joliba or Niger; and from the other to the Gambia, Senegal, and to other rivers which run into the Atlantic over a rich cultivated plain, but unhealthy from the rankness of the vegetation.

§ 9. The moisture that descends from the northern edge of the table-land of South Africa, under the fiery radiance of a tropical sun, fertilizes a tract of country stretching from sea to sea across the continent, the commencement of the African low lands. A great part of this region, which contains many kingdoms and commercial cities, is a very productive country. The abundance of water, the industry of the natives in irrigating the ground, the periodical rains, and the tropical heat, leave the soil no repose. Agriculture is in a rude state, but nature is so bountiful that rice, millet, and other grains are raised in sufficient quantity to supply the wants of a numerous population. Gold is found in the river-courses, and elephants abound in the forests; but slaves form the staple of their commerce.

In the very centre of this fine country lies lake Tchad, almost like a sea, and receiving many fine large rivers, especially the Shary and Mayo; the latter is mentioned by Dr. Barth as only to be compared with the Nile at highest flood. The celebrated port of Kábara, near which the city of Timbuctu is situated, is several miles from the river, and only accessible during five months in the year, when the rains are heavy. It is in 17° 30′ N. lat., and 3° W. long.

This long belt of never-fading vitality, which has its large lakes, poisonous swamps, deep forests of gigantic trees, and vast solitudes in which no white man ever trod, is of small width compared with its length. In receding from the mountains, the moisture becomes less and the soil gradually worse, sufficing only to produce grass for the flocks of the wandering Bedouin. At last a hideous barren waste begins, which extends northwards 800 miles in unvaried desolation to the grassy steppes at the foot of the Atlas; and for 1000 miles between the Atlantic and the Red Sea the nakedness of this blighted land is unbroken but by the valley of the Nile and a few oases in its neighbourhood.

In the W. about 760,000 miles, an area equal to that of the Mediterranean Sea, and, in some parts, of a lower level, is covered by the trackless sands of the Sahara desert, which is even prolonged for miles into the Atlantic Ocean in the form of sand-banks. This desert is alternately scorched by heat and pinched by cold. The wind blows from the E. nine months in the year; and at the equinoxes it rushes in a hurricane, driving the sand in clouds before it, producing the darkness of night at midday, and overwhelming caravans of men and animals in common destruction. Then the sand is heaped up in waves ever varying with the blast; even the atmosphere is sand. The desolation of this dreary waste, boundless to the eye as the ocean, is terrific and sublime; the dry heated air is like a red vapour, the setting sun seems to be a volcanic fire, and at times the burning wind of the desert is the blast of death. There are many salt lakes to the N., and even the springs are of brine; thick incrustations of dazzling salt cover the ground, and the particles, carried aloft by whirlwinds, flash in the sun like diamonds.

Sand is not the only character of the desert; tracts of gravel and low bare rocks occur at times, not less barren and dreary; but on the eastern and northern borders of the Sahara fresh water rises near the surface, and produces an occasional oasis where barrenness and vitality meet. The oases are generally depressed below the level of the desert, with an arenaceous or calcareous border enclosing their emerald verdure like a frame. The smaller oases produce herbage, ferns, acacias, and some shrubs; forests of date-palms grow in the larger, which are the resort of lions, panthers, gazelles, reptiles, and a variety of birds.

In the Nubian and Libyan deserts, to the E. of the Sahara, the continent shelves down towards the Mediterranean in a series of terraces, consisting of vast level sandy or gravelly deserts, lying E. and W., separated by low rocky ridges. This shelving country, which is only 540 feet above the sea at the distance of 750 miles inland, is cut transversely by the Nile, and by a deep furrow parallel to it, in which there is a long line of oases. This furrow, the Nile, and the Red Sea, nearly parallel to both, are flanked by rocky eminences which run N. from the table-land.

On the interminable sands and rocks of these deserts no animal—no insect—breaks the dread silence; not a tree nor a shrub is to be seen in this land without a shadow. In the glare of noon the air quivers with the heat reflected from the red sand, and in the night it is chilled under a clear sky sparkling with its host of stars. Strangely but beautifully contrasted with these scorched solitudes is the narrow valley of the Nile, threading the desert for 1000 miles in emerald green, with its waters foaming with rapids among wild rocks, or quietly spreading in a calm stream amidst fields of corn and the august monuments of past ages.

At the distance of a few days' journey W. from the Nile, over a hideous flinty plain, lies the furrow already mentioned, trending to the N., and containing the oases of Darfur, Selime, the Great and Little Oases, and the parallel valleys of the Natron Lakes, and Bahr-

Belama or the "Dry River." The Great Oasis, or Oasis of Thebes, is 120 miles long and 4 or 5 broad; the Lesser Oasis, separated from it by 40 miles of desert, is of the same form. Both are rich in verdure and cultivation, with villages amid palm-groves and date-plantations, mixed with the ruins of remote antiquity, offering scenes of peaceful and soft beauty contrasted with the surrounding gloom. The Natron Lakes are in the northern part of the Valley of Nitrùn, 35 miles W. of the Nile; the southern part is a beautiful retired spot, that became the retreat of Christian monks in the middle of the second century, and at one time contained 360 convents, of which only 4 remain; from these some ancient valuable manuscripts have been obtained.

Another line of oases runs along the latitude of Cairo, with fresh-water lakes no less fertile than the preceding. In one of them are the ruins of the Temple of Jupiter Ammon.

Hundreds of miles on the northern edge of the desert, from the Atlantic along the southern foot of the Atlas to the Great Syrtis, are pasture-lands without a tree—an ocean of verdure. At the Great Syrtis the Sahara reaches the shores of the Mediterranean; and, indeed, for 1100 miles between the termination of the Atlas and the little table-land of Barca, the ground is so unproductive that the population only amounts to about 30,000, and these are mostly wandering tribes who feed their flocks on the grassy steppes. Magnificent countries lie along the Mediterranean coast N. of the Atlas, susceptible of cultivation. History, and the ruins of many cities, attest their former splendour; even now there are many populous commercial centres, and much grain is raised, though a great part of these valuable kingdoms is badly cultivated or not cultivated at all.

§ 10. The base of the sandy parts of North Africa is stiff clay; in Lower Nubia, between the parallels of Assouan and Esneh, red and white granite prevail, followed by argillaceous slates and sandstone; Middle Egypt is calcareous, for the great band of nummulite limestone, so ably traced by Sir R. Murchison over nearly a third of the globe, from the Bay of Biscay to the shores of Aracan, crosses Africa between the parallels of 16° and 20° of N. lat., and lower down the surface is covered by the alluvial deposits of the Nile.

It would appear that Southern Africa, though similar in its unbroken surface and peninsular shape to South America, bears no resemblance to it in other respects, but has a great analogy to the Deccan in its triangular form, its elevated platform, and in the position of its encompassing mountain-chains, if, as there is reason to believe, from the fertile region to the N., either that South Africa descends in a succession of terraces to the low lands, or that the Komri mountains have a real existence, and run directly across the continent; besides, there is evidence that the tertiary strata on the table-land, as in the Deccan, have been the basin of a great fresh-water lake.[1]

The prodigious extent of desert is one of the most extraordinary circumstances in the structure of the old continent. A zone of almost irretrievable desolation of at least 120 degrees of longitude prevails from the Atlantic Ocean across Africa and through Central Asia almost to the shores of the Pacific, because this long tract is flanked by an almost continuous chain of mountains and table-lands which drain the prevailing winds of their moisture. There are also many large districts of the same sterile nature in Europe; and if to these sandy plains the deserts of Siberia be added, together with all the barren and rocky mountain tracts, the unproductive land in the Old World is prodigious. The quantity of salt on the sandy plains is great, and proves that they have been part of the bed of the ocean or of inland seas at no very remote geological period. The low lands round the Black and Caspian Seas, and the Lake of Aral, seem to have been the most recently raised from the sea, from the great proportion of shells in them identical with those now existing in these seas. The same may be said of the Sahara desert, where salt and recent shells are plentiful.

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[1] Johnston's Physical Atlas.

BIBLIOTHECA BODLEIANA

CHAPTER IX.

THE CONTINENT OF AMERICA.

§ 1. General view of the American Continent. § 2. Mountain systems of South America; the Andean chain. § 3. The Chilian Andes; proposed railway; vegetation. § 4. The Peruvian Andes. § 5. Character of South American table-lands; valley of the Desaguadero; city of Cusco. § 6. Transverse ranges of the Andes; valley of Quito. § 7. Passes of the Andes. § 8. Climate of the Andes. § 9. Low lands east of the Andes; mountains of the Parima. § 10. Table-land of Brazil; Brazilian mountain chains.

§ 1. Some thinner portion of the crust of the globe under the meridians that traverse the continent of America, from Cape Horn to the Arctic Ocean, must have yielded to the expansive forces of the subterranean fires, or been rent by contraction of the strata in cooling. Through this the Andes have arisen, producing the greatest influence on the form of the continent, and the peculiar simplicity that prevails in its principal mountain systems, which, with very few exceptions, have a general tendency from N. to S. The continent is 9000 miles long, and consisting of two great peninsulas joined by a long narrow isthmus, it is divided by nature into the three parts of South, Central, and North America; yet these three are connected by the mighty chain of the Andes, and its continuation, the Rocky Mountains, running parallel to the Pacific from within the Arctic nearly to the Antarctic circle. In this course every variety of climate is to be met with, from the rigour of polar congelation to the scorching heat of the torrid zone; while the mountains are so high that the same extremes of heat and cold may be experienced in the journey of a few hours from the burning sands which form the coasts of Peru to the snow-clad peaks that tower above them. In this long chain there are three distinct varieties of character, nearly, though not entirely, corresponding to the three natural divisions of the continent. The Andes of South America differ materially from those of Central America and Mexico, while both are dissimilar to the North American prolongation of the chain.

§ 2. The greatest length of South America from Cape Horn to the Isthmus of Panama is about 4020 geographical miles. It is very narrow at its southern extremity, but increases in width northwards to the latitude of Cape San Roque on the Atlantic, between which and Cape Blanco on the Pacific it attains its greatest breadth, of nearly 2750 miles. It consists of three mountain systems, separated by the basins of three of the greatest rivers in the world. The Andes run along the western coast from Cape Horn to the Isthmus of Panamá, in a single chain of inconsiderable width, but majestic height, dipping rapidly to the narrow plains on the Pacific, but descending on the east by huge spurs or offsets, and deep valleys, to plains of vast extent, whose level is for hundreds of miles as unbroken as that of the ocean by which they are bounded. Nevertheless two detached mountain systems rise from these plains, one in Brazil between the Rio de la Plata and the river Amazon; the other that of Parima and Guiana, between the river Amazon and the Orinoco.

The great chain of the Andes first raises its crest above the waves of the Antarctic Ocean in the majestic sombre mass of Cape Horn, the southernmost point of the archipelago of Tierra del Fuego. This group of mountainous islands, equal in size to Great Britain, is separated from the mainland by the Strait of Magellan. The islands are penetrated in every direction by bays and narrow inlets of the sea, or fiords, ending often in glaciers fed by the snow on the summits of mountains 6000 feet high. Peat-mosses cover the higher declivities of these mountains, and their flanks are covered with densely entangled forests of brown beech, which never lose their dusky leaves, producing altogether a savage and melancholy landscape. The mountains which occupy the western side of this cluster of islands sink down in extensive plains towards the east, like the continent itself, of which the archipelago is but the southern prolongation.[1]

The Pacific washes the very base of the Patagonian Andes for about 1000 miles, from Cape Horn to the 40th parallel of S. latitude. The whole coast is lined by a succession of archipelagos and islands, separated from the iron-bound shores by narrow arms of the sea, which, in the more southern part, are in fact profound longitudinal valleys of the Andes filled by the ocean, so that the islands running parallel to the axis of these mountains are but the summits of an exterior range rising above the sea.

The coast itself for 650 miles is begirt by walls of granite rock, which sink into unfathomable depths, torn by long crevices or fiords similar to those on the Norwegian shore, and ending in tremendous glaciers, whose masses, falling with a crash like thunder, drive the sea in sweeping breakers through these chasms. The islands and the mainland are thickly clothed with forests, which are of a less sombre aspect as the latitude decreases; and more to the N. there are fertile plains inhabited by a rude people, but capable of supporting large populations, and into which Chilian civilization is advancing.

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[1] The surveys of the late Admiral P. B. King and Admiral Fitzroy, Mr. Darwin's 'Journal of a Naturalist,' Dr. Pöppig's 'Travels in South America,' are the authorities from which the author has drawn for the account of Tierra del Fuego, Patagonia, and Chile; Humboldt, Mr. Pentland, Drs. Pöppig and Meyer, of Berlin, for Peru and the Andean Chain to the Isthmus of Panamá.

§ 3. Between the Pass of Chacabuco, N. of Santiago, the capital of Chile, and the archipelago of Chiloe, a chain of hills, composed in general of granite rocks, borders the coast; between which and the Andes exists a longitudinal valley, well watered by the rivers descending from the central chain, and which constitutes the most fertile portion, nay, the garden of the Chilian republic—the rich provinces of Santiago, Talca, Cauquenes, and Concepcion. This longitudinal depression may be considered as a prolongation northwards of the strait that separates Chiloe from the mainland. Many peaks of the Andes enter within the limits of perpetual snow, between the 40th and 31st parallels; some of which are active volcanoes. In lat. 32° 39′ S. rises the giant of the American Andes, the Nevado of Aconcagua, which towers over the Chilian village of the same name, and is clearly visible from Valparaiso. Although designated as a volcano, a term generally applied in Chile to every elevated and snowy peak, it offers no trace of modern igneous origin. It appears to be composed of a species of porphyry generally found in the centre of the Chilian chain. Its height, according to Admiral Beechey's very accurate observations, exceeds 23,910 feet.[1] And in the same group, but farther south, lies the Nevado of Tupungato. The line of perpetual snow makes a remarkable bend in Chile; in lat. 33° 8′ S. it is 12,780 feet above the sea-level; seven degrees farther S., on the parallel of Valdivia, it sinks to 8300; and at Copiapo it rises to 13,800. There is a gigantic project of carrying a railway over the Chilian Andes from Copiapo, across the Argentine Provinces, to Rosario, on the river Parana, which has led to a survey extending 350 miles over the Great Cordillera, and the slopes and plains beyond to the Parana.

About the latitude of Concepcion the dense forests of araucarias and of other semi-tropical plants cease with its humid equable climate; and as no rain falls in Central Chile for nine months in the year, the brown, purple, and tile-red hills and mountains are only dotted here and there with low trees and bushes; very soon, however, after the heavy showers have moistened the cracked ground, it is covered with a beautiful but transient flora. In some valleys it is more permanent and of a tropical character, mixed with alpine plants.[1] In Northern Chile rain falls only once in two or three years, the consequence of which is sterility on the western precipitous and unbroken descent of the Andes: on the E., two secondary groups separate from the Central Cordillera, which extend 300 or 400 miles into the plains, are wooded to a great height. The Sierra de Cordova, the most southern of these, commences between the 33rd and 31st parallels, and extends in the direction of the Pampas; more to the north the mountains of Salta and Jujuy stretch from the valley of Catamarca and Tucuman towards the Rio Vermejo, one of the tributaries of the Rio de la Plata.

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[1] This great height has been deduced, adopting the position of the Peak as fixed by Admiral Fitzroy, and employing the angles of elevation observed near Valparaiso by the late Admiral Beechey. Lieut. Gillies, of the American Astronomical Expedition to Chile, gives only 22,200 feet for the altitude of this Nevado.

To the N. of Chile succeeds the province of Atacama stretching from the sea to the snowy Cordillera, a region of desolate sands and bare rock, without water or vegetation, and with scarcely a living creature. Two years have sometimes passed without a shower. The chief town, S. Pedro de Atacama, at the north extremity of a great salt lake, contains 5000 inhabitants; along its river there is some cultivation. The valley of Atacama is about 7400 feet above the sea; in the Andes W. of it rise several very elevated peaks, one of which, Hlaska, 19,600 feet high, is an active volcano, constantly emitting smoke from its summit. About 100 miles S. of this is the mountain of Llullayacu, one of the most elevated peaks in the Chilian Andes, after that of Aconcagua.

§ 4. The chain takes the name of the Peruvian Andes about the 24th degree of S. latitude, and is separated from the Pacific by a range of hills composed of crystalline rocks, parallel to the sea-coast, and by an intervening sandy desert, seldom above 60 miles broad, on which rain scarcely ever falls, where bare rocks pierce through the moving sand. The width of this coast region is nearly the same to the Isthmus of Panamá, but damp luxuriant forests, full of orchidaceous plants, begin to show themselves about the latitude of Payta, and continue northwards through the provinces of Guayaquil, Las Esmeraldas, and Darien.

From their southern extremity to the Nevado of Chorolque, in 21° 30′ S. lat., the Peruvian Andes form one grand and continuous range of mountains, but N. of that peak the chain divides into two longitudinal ridges, which enclose a series of valleys or tablelands, forming so many basins, separated at various points by transverse groups or mountain-knots, or by single ranges crossing between them like dykes, a structure that prevails to Pasto, 1° 13′ N. lat.

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[1] Dr. Pöppig's Travels.

§ 5. Unlike the table-lands of Asia at great elevations, where cultivation is confined to the more sheltered spots, or those still lower in Europe, which are only fit for pasture, these lofty regions of the Andes yield exuberant crops of every kind of European grain, and have many populous cities enjoying the luxuries of civilized life, with universities, libraries, civil and religious establishments, at altitudes equal to that of the Peak of Teneriffe, which is 12,170 feet above the sea-level. Villages are situated and mines are worked at heights as great or even greater than the top of Mont Blanc.[1] This state is not limited to the present times, since these table-lands were made the centre of civilization by a race of men which "bear the same relation to the Incas and the present inhabitants that the Etruscans bear to the ancient Romans and to the Italians of our own days."

The table-land or valley of the Desaguadero, one of the most remarkable of these basins, has an absolute altitude of 12,900 feet and a breadth varying from 30 to 60 miles: it stretches 400 miles between the two parallel chains of the Andes, and between the transverse mountain-groups of Lipez, in 20° S. lat., and the great mountain-knot of Vilcañota, which, extending from E. to W., shuts in the valley on the N.W.; it occupies an area three times as large as Switzerland, some of the snowy peaks rising 8300 feet above the surface of the table-land, from which an idea may be formed of the gigantic scale of this portion of the Andes. This valley is bounded on each side by the two grand chains of the Peru-Bolivian Andes: that on the west is the Cordillera of the coast; the range on the E. is the Bolivian Cordillera, properly speaking, called in its N.W. prolongation the Cordillera Real.[2] These two rows of mountains lie so near to each other that the whole breadth of the table-land, including both, is only 226 miles. All the snowy peaks of the Cordilleras of the coast are either active volcanoes or of igneous origin, and are all situate near the maritime declivity of the chain; consequently, the descent to the shores of the Pacific is everywhere very abrupt. The eastern Cordillera, which begins near the metalliferous mountain of Potosi, is below the level of perpetual snow to the S., but its northern portion contains the three peaked mountains of Ancohuma or the Nevado of Sorata, of Supäíwasi, and Illimani, and is one of the most magnificent portions of the Andes.[1] The snowy part begins with the gigantic mass of Illimani, whose serrated ridges are elongated in the direction of the axis of the chain. The lowest glacier on its southern slope does not descend below 16,500 feet, and the valley of Tortoral, a mere gulf in which Vesuvius might stand, comes between Illimani and the Nevado of La Mesada, from whence the eastern Cordillera runs to the N.W. in a continuous line of snow-clad peaks to the group of Vilcañota, where it unites with the western. The sharp and serrated chain on the E. forms a striking contrast with the conical and dome-shaped Cordillera of the coast. All the rivers and streams that rise on the E. side of the Cordillera of the coast flow to the affluents of the Amazon, through the deep gorges in the eastern Cordillera between Illimani and the Nevado of Sorata.

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[1] The celebrated silver mines of Potosi were, until within the last fifty years, worked to the very summit of that metalliferous mountain, 16,150 feet above the sea-level.

[2] Humboldt and Mr. Pentland.

The valley of the Desaguadero, occupying 150,000 square miles, has a considerable variety of surface; in the south, throughout the mining districts, it is cold and unproductive. Potosi, the highest city in the world, stands at an absolute elevation of 13,330 feet, at the foot of a mountain celebrated for its silver-mines. Chuquisaca, the capital of Bolivia, containing 13,000 inhabitants, lies to the N.E. of Potosi, in the midst of a cultivated district. The northern part of the valley is populous, and produces barley, potatoes, and in sheltered situations even wheat and maize; and the Lake of Titicaca, twenty times as large as the Lake of Geneva, fills the northwestern portion of this great basin. The islands and shores of this lake still exhibit ruins of gigantic magnitude, monuments of a people more ancient than the Incas. The modern city of La Paz with 40,000 inhabitants, a few leagues from its southern shores, stands in the bottom of a deep ravine, on each side of an impetuous torrent, descending from the neighbouring snowy peaks, having in full view the vast Nevado of Illimani to the E.S.E., at a distance of seven leagues.

Many offsets diverge from the eastern side of the Bolivian Cordillera, which terminate in the great plains of Chiquitos and Paraguay; the most important is the Cordillera of Yuracaraës, which bounds the rich valley of Cochabamba on the N., and ends near the town of Santa Cruz de la Sierra.

There are some fertile valleys in the snow-capped group of Vilcañota and Cusco. The city of Cusco, which contains nearly 50,000, inhabitants, was the capital of the empire of the Incas: it still contains numerous ruins of that dynasty, among which the remains of the Temple of the Sun, and the Cyclopean fortress that towers over it to the N., still mark its former splendour. Four ancient Peruvian roads led from Cusco to the different parts of the empire, little inferior in many respects to the old Roman ways: all crossing mountain-passes higher than the summit of the Peak of Teneriffe. On the northern prolongation of the chain, in lat. 11° S., encircled by the Andes, is the elevated plain of Bombon, near to the celebrated silver-mines of Pasco, at a height of 14,000 feet above the sea. In it is situated the Lake of Lauricocha, which may be considered, from its remoteness, as one of the sources of the Amazon. There are many small lakes on the table-lands and high valleys of the Andes, some even within the range of perpetual snow. They are very cold and deep, often of the purest sea-green colour.

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[1] The breadth of the table-land, and the two cordilleras of the Bolivian Andes, given in the text, was measured by Mr. Pentland; he also determined the heights of Illimani to be 21,150 feet; of Supäíwasi, or Huayna Potosi, 20,260 feet; and of Ancohuma, or the Nevado of Sorata, 21,290 feet.

§ 6. The chain of the Andes is divided into three ranges of mountains running from S. to N. in the transverse group or mountain-knot of Pasco and Huanuco, which shuts in the valley of Bombon between the 11th and 10th parallels of S. latitude: that in the centre separates the wide fertile valley of the Upper Marañon from the still richer valley of the Huallaga, whilst the more eastern forms the barrier between the latter and the tropical valley of the Yucayali. The western chain alone attains the limit of perpetual snow, and, if we except the Nevado of Huaylillas, in 7° 50′ S., no mountain N. of this for nearly 400 miles to the Andes of Quito reaches the snow-line.

In lat. 4° 50′ S. the Andes form the mountain-knot of Loxa, celebrated for its forests, in which the Cinchona or Peruvian bark was first discovered. From this knot the chain divides into two great longitudinal ridges or cordilleras, in an extent of 350 miles passing through the republic of the Equator to the mountain-group of Los Pastos in that of New Grenada. These ridges enclose a great longitudinal basin, which, divided by the cross ridges of Assuay and Chisinche into three portions, forms the valleys of Cuenca, La Tapia, and Quito. The plain of Cuenca offers little interest; that of La Tapia is magnificent; whilst the valley of Quito is one of extraordinary beauty: on either side rise a series of snow-capped peaks, as much celebrated in the history of of science as the valley itself is in that of the aboriginal races of the New World. Here the energies of volcanic action have been studied with the greatest advantage; here, more than 100 years ago, was executed that measurement of an arc of the meridian which afforded the most accurate data at the time towards the determination of the mass and form of our planet, and which has conferred eternal honour on the body with which it originated, the French Academy of Sciences; and celebrity on the names of

Bouguier, La Condamine, Juan, Ulloa, and Godin, who conducted it on the part of the crowns of France and Spain.

The cordillera or ridge which hems in the valley of Quito on the E. contains the snow-capped peaks of Antisana, Cotopaxi, one of the most beautiful of active volcanoes, whose dazzling cone rises to a height of 18,775 feet, of Tungaragua, of el-Altar—once equal to Chimborazo in height—and Sangay. The western range includes the gigantic Chimborazo, which may be seen from the coasts of the Pacific, and the pyramidal peak of Illinissa, the wreck of an ancient volcano. As the Illinissa is seen from the ocean, its absolute height was measured by the direct observations of the French Academicians, whence the absolute elevation of the valley of Quito, and of the other peaks that encircle it, was deduced, as well as the earliest approximate value of the barometrical coefficient. North of Chimborazo, and near it, is the Carguäirazo; and close to the city of Quito rises the scarcely less celebrated volcano of Pichincha; whilst the Nevado of Cayambè—whose summit, elevated 19,535 feet, is traversed by the equator—perhaps the greatest and most remarkable landmark on the earth's surface, closes the north-east extremity of this great Andean depression.

The valley of Quito, one of the finest in the Andes, is 200 miles long and 30 wide, with a mean elevation above the sea of 10,000 feet, and bounded by the most magnificent series of volcanic mountains in the New World. A peculiar interest is attached to two of the many volcanoes in the parallel cordilleras that flank it. The beautiful snow-clad cone of Cayambè Urcu, as already stated, traversed by the equator, closes it on the north; and on the western side the cross still stands on the summit of Pichincha, 15,924 feet above the Pacific, which served as a signal to Bouguier and La Condamine in their memorable measurement of the equatorial arc of the meridian.[1]

Some parts of the plain of Quito to the S. are sterile, but the soil generally is fertile, and perpetual spring clothes it with exuberant vegetation. The city of Quito, at the base of Pichincha, containing 70,000 inhabitants, has an absolute height of 9540 feet. It is regularly and well built; the churches are rich; it possesses an university, and many of the comforts and luxuries of civilized life, in a situation of unrivalled grandeur. Thus, on the very summit of the Andes there is a world by itself, with its mountains and its valleys, its lakes and rivers, populous towns and cultivated fields. Many monuments of the Incas are still found in good preservation in these plains, where the scenery is most noble—eleven volcanic cones are visible from one spot. Although the Andes are inferior in height to the Himalaya, yet the domes of trachyte, the truncated cones of the active volcanoes, and the serrated ruins of those that are extinct, mixed with the bold features of primary mountains, give an infinitely greater variety to the scene, while the smoke, and very often the flame, issuing from these regions of perpetual snow, increase its sublimity. Stupendous as these mountains appear even from the plains of the table-land, they are merely the inequalities of the tops of the Andes, the serrated summit of that mighty chain.

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[1] Humboldt.

Between the large group of Los Pastos, containing several active volcanoes, and the group of Las Papas, in the 2nd degree of N. latitude, the bottom of the valley is only 6920 feet above the sea; and N. of the latter mountain-knot the crest of the Andes splits into 3 cordilleras, which diverge, not again to unite. The most westerly of these, the range of Choco, which may be considered the continuation of the great chain, separates the valley of the river Cauca from the Pacific; it is only 5000 feet high, and the lowest of the three. Though but 20 miles broad, it is so steep and so difficult of access that travellers cannot cross it on mules, but are carried on men's shoulders; it is rich in alluvial deposits of gold and platina. The central branch, or Cordillera of Quindiu, runs due N. between the valleys of the Magdalena and Cauca, rising to a great height in the volcanic peak of Tolima. The two last chains are united by the mountain-knot of Antioquia, of which little more is known than that it forms two great masses, which, after separating the streams of the Magdalena, Cauca, and Atrato, trends to the N.W., greatly reduced in height, and with the chain of Choco forms the low mountains of the Isthmus of Panamá. The most easterly of the three cordilleras, called the Sierra de la Summa Paz, spreads out on its western declivity into the table-lands of Bogota, Tunja, &c. &c., the ancient Cundinamarca, which have an elevation of about 9000 feet; whilst on its eastern slope are the sources of the rivers Guaviari and Meta, the head-waters of the Orinoco. The great natural crevice of Icononzo occurs in the path leading from the city of Bogota to the banks of the Magdalena. It probably was formed by an earthquake, and is like an unfilled mineral vein, across which are two natural bridges: the lowest is composed of stones that have been jammed between the rocks in their fall.[1] This cordillera comprises the Andes of Cundinamarca and Merida, and runs in a north-eastern direction through New Granada to the 10th northern parallel, where it joins the coast-chain of Venezuela or Caraccas, and ends at Cape Paria in the Caribbean Sea, or rather at the eastern extremity of the island of Trinidad. This coast-chain is so majestic and beautiful that Baron Humboldt says it is like the

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[1] Humboldt.

Alps rising out of the sea without their snow. The insulated group of Santa Martha, 19,000 feet high, deeply covered with snow, stands on an extensive plain between the delta of the Magdalena and the sea-lake of Maracaybo, and is a landmark to mariners far off in the Caribbean Sea.

§ 7. The passes over the Chilian Andes are numerous; the double one of the Portillo, leading from Santiago to Mendoza, is the highest; it crosses two ridges, one of which is so high that vegetation ceases far below its summit. Those in Peru are higher, though very few reach the snow-line. In Bolivia the mean elevation of the passes in the western and eastern cordillera is 14,892 and 11,422 feet respectively. That leading from Sorata to the auriferous valley of Tipuani is perhaps the highest in Bolivia. From the total absence of vegetation and the intense cold, it is supposed to exceed 16,000 feet above the Pacific. The pass of Quindiu, in New Granada, though not so high, is the most difficult of all across the Andes; but those crossing the mountain-knots from one table-land to another are the most dangerous. The road over the Paramo del Assuay, in the plain of Quito, is nearly as high as Mont Blanc; and travellers not unfrequently perish from cold winds in attempting it.[1]

§ 8. On the western side of the Peruvian Andes little or no rain falls, except at their most southern extremity; and scanty vegetation appears only on spots or in small valleys watered by streams from the Andes. Excessive heat and moisture combine to cover the eastern side and its offsets with tangled forests of large trees and dense brushwood. This exuberance diminishes as the height increases, till at last the barren rocks are covered only by snow and glaciers. In the Andes near the equator glaciers descending below the snow-line are unknown. The steepness of the declivities and the dryness of the air at such great elevations prevent any accumulation of infiltrated water: the annual variations of temperature, besides, are small. Nothing can surpass the desolation of these regions, where nature has been shaken by terrific convulsions. The dazzling snow fatigues the eye; the huge masses of bold rock, the mural precipices, and the chasms yawning into dark unknown depths, strike the imagination; while the crash of the avalanche or the rolling thunder of the volcano startles the ear. In the dead of night, when the sky is clear and the wind hushed, the hollow moaning of the volcanic fire fills the Indian with superstitious dread in the death-like stillness of these solitudes.

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[1] It appears by the measurements of Mr. Pentland in the Peru-Bolivian Andes that many of their passes are higher than in the equatorial portion of the chain. The passes of Rumihuasi, on the high-road from Cusco to Arequipa, of Toledo (between Arequipa and Puno), of Gualillas and Chullunquiani (between Arica and La Paz), all in the Western Cordillera, attain the respective elevations of 16,160; 15,790; 14,750; and 15,160 feet; whilst in the Eastern or Bolivian Cordillera the passes of Challa (between Oruro and Cochabamba), of Pacuani (between La Paz and Coröico), of Pumapacheta (between the lake of Titicaca and the affluents to the Amazon), of Vilcañota (between the valley of the Collao and that of the river Yucay), rise to the heights of 13,600; 13,350; 13,600; and 14,520 English feet.

In the very elevated plains between the transverse groups, such as that of Bombon, however pure the sky, the landscape is lurid and colourless; the dark-blue shadows are deeply defined, and from the thinness of the air it is hardly possible to make a just estimate of distance. Changes of weather are sudden and violent; clouds of black vapour arise, and are carried by fierce winds over the barren plains; snow and hail are driven with irresistible impetuosity; and thunder-storms come on, loud and awful, without warning. Notwithstanding the thinness of the air, the crash of the peals is quite appalling; while the lightning runs along the scorched grass, and, sometimes issuing from the ground, destroys a team of mules or a flock of sheep at one flash.[1]

Currents of warm air are occasionally met with on the crest of the Andes—an extraordinary phenomenon on such gelid heights, which is not yet explained; they generally occur two hours after sunset, are local and narrow, not exceeding a few fathoms in width, similar to the equally partial blasts of hot air in the Alps. A singular instance, probably of earth-light, occurs in crossing the Andes from Chile to Mendoza. On this rocky scene a peculiar brightness occasionally rests, a kind of undescribable reddish light, which vanishes during the winter rains, and is not perceptible on sunny days. Dr. Pöppig ascribes the phenomenon to the dryness of the air; he was confirmed in his opinion from afterwards observing a similar brightness on the coast of Peru, and it has also been seen in Egypt.

The Andes S. of Peru descend to the eastern plains by a series of cultivated terraces, as those of Tucuman, Salta, and Jujuy, in the republic of La Plata. That of Tucuman is 2500 feet above the sea. In Peru the descent to the E. is more precipitous; all the streams flow to the plains down stupendous ravines or *quebradas*, the heights dividing one water-course from another being so steep and lofty that the traveller has to make a wide circuit to pass from valley to valley. In descending by the banks of the rivers, the change is rapid, from the cool region of scanty vegetation down to the sweltering plains, where grow the banana and sugar-cane in tropical luxuriance.

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[1] Pöppig.

Light mists hang over the forest landscape in early morning, and the gleam of leaping cascades from the neighbouring heights adds to the glory of the scene. Further N., on the Huallaga, the Andes end abruptly like a steep wall, and the transition is sudden from the region of mountains to that of the Amazon plains, which extend almost without inequalities from the foot of the mountain wall to the Atlantic.

§ 9. The low lands to the E. of the Andes are divided by the table-lands and mountains of Guiana and Brazil into three parts of very different aspect—the deserts and Pampas of Patagonia and Buenos Ayres, the forest plains of the Amazon, and the Llanos or grassy steppes of the Orinoco. The eastern table-lands nowhere exceed 2500 feet of absolute height. The plains are so low and flat, especially at the foot of the Andes, that a rise of 1000 feet in the Atlantic Ocean would submerge more than half the continent of South America.

The system of Parima or Guiana is a group of mountains scattered over a table-land not more than 2000 feet above the sea, which extends 600 or 700 miles from E. to W., between the river Orinoco, the Rio Negro, the Amazon, and the Atlantic Ocean. It is quite unconnected with the Andes, being 80 leagues E. from the mountains of New Granada. It begins 60 or 70 miles from the coast of Venezuela, ascends by four successive terraces to undulating plains, which reach to within one or two degrees of the equator, and is twice as long as it is broad.

Seven chains, besides groups of mountains, traverse the table-land from W. to E., of which the chief is the Sierra del Parima. Beginning at the mouth of the Meta, it crosses the plains of Esmeralda to the frontier of Brazil. This chain is not more than 600 feet high, is everywhere abrupt, and forms the watershed between the tributaries of the Amazon and of the Orinoco. The Orinoco rises on the northern side of the Sierra del Parima, and in its circuitous course over the plains of Esmeralda it breaks through that chain and the parallel one of the Maypures 36 miles to the S.: dashing with violence against the transverse shelving rocks and dykes, it forms the magnificent series of rapids and cataracts of Maypures and Atures, from whence the Parima mountains have got the name of the Cordillera of the Cataracts of the Orinoco. The chain is of granite, which forms the banks and fills the bed of the river, covered with luxuriant tropical vegetation, especially palm-forests. In the district of the Upper Orinoco, near Charichana, there is a granite rock which emits musical sounds at sunrise, like the notes of an organ, occasioned by the difference of temperature of the external air and that which fills the deep narrow crevices with which the rock is everywhere torn. Something of the same kind occurs at Mount Sinai, but the sound is there caused by the friction of moving sand.[1]

The other parallel chains that extend over the table-land in Venezuela and Guiana, though not of great height, are rugged, and often crowned with mural ridges: they are separated by flat savannahs, generally barren in the dry season, but after the rains covered with a carpet of long emerald-green grass, mixed with flowers. The vegetation in these countries is beautiful beyond imagination. The regions of the Upper Orinoco and Rio Negro, and of almost all the mountains and banks of rivers in Guiana, are clothed with majestic and impenetrable forests, whose moist and hot recesses are the favourite abode of the singular and beautiful family of the Orchideæ.

Although all the mountains of the system of Parima are wild and rugged, they are not high. The inaccessible peak of the Cerro Duida, which rises insulated 7155 feet above the plain of Esmeralda, is the culminating point, and one of the highest mountains in South America E. of the Andes. The fine savannahs of the Rupununi were the country of romance in the days of Queen Elizabeth. S. of Pacaraime, near an inlet of the river, the far-famed city of Manoa was supposed to stand, the object of the unfortunate expedition of Sir Walter Raleigh; about 11 miles S.W. of which is situate the lake Amucu, "the Great Lake with golden banks"—great only during the periodical floods.[2] Gold has lately been rediscovered in this region between the Imataca hills and the Cuyuni river, and flourishing establishments, called the gold-mines of Caratal, are drawing population and capital to the country—a welcome justification of the reports which attracted our great countryman.

§ 10. On the southern side of the basin of the river Amazon lies the table-land of Brazil, having a mean height of about 2500 feet, which occupies half that empire, together with part of the republics of the Rio de la Plata and Uruguay. Its form is a triangle, whose apex is at the confluence of the rivers Mamoré and Beni; and its base extends, near the shores of the Atlantic, from the mouth of the Rio de la Plata to within three degrees of the equator. It is difficult to define the limits of this vast territory, but some idea may be formed of it by following the directions of the rapids and cataracts of the rivers descending from it to the plains around. Thus a line drawn from the fall of the river of the Tocantins, in 3° 30′ S. latitude, to the cataracts of the Madeira, in the 8th degree of S. latitude, will nearly mark its northern boundary; from thence the line would run S.W. to the junction of the Mamoré and Beni; then turning to the S.E. along the ridges of mountains called the Cordillera Geral, and Sierra Parecis, it would proceed S. to the cataract of the Paraná, called the Sete Quedas, in 24° 30′ S. latitude; and lastly from thence, by the great falls of the river Iguassu, to the Morro de Santa Martha, in latitude 28° 40′, S. of the island of St. Catherine.

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[1] Humboldt.

[2] Humboldt's Personal Narrative.

Chains of mountains, nearly parallel, extend from S.W. to N.E. 700 miles along the base of the triangle, with a breadth of about 400 miles. Of these, the Sierra do Mar, or the "coast-chain," reaches from the river Uruguay to Cape San Roque, never more distant than 20 miles from the Atlantic, except to the S. of the bay of Santos, where it is 80. It is the richest botanical region in Brazil. Offsets diverge to the right and left; the granitic peaks of the Corcovado and Tejuco, which form such picturesque objects in that most magnificent of panoramas, the bay of Rio de Janeiro, are the extremities of one. The parallel chain of Espinhaço, beginning near the town of San Paolo, and the continuous chains of the Serra Frio, forming the western boundary of the basin of the Rio San Francisco, is the highest in Brazil, one of its mountains, Itambe, being 8426 feet above the sea. All the mountains in Brazil have a general tendency from S.W. to N.E., except the transverse chain of the Sierra dos Vertentes, which rises 60 miles S. of Villa Rica, and runs in a tortuous line to its termination near the junction of the Mamoré and Beni. It forms the watershed of the tributaries of the San Francisco and Amazon on the N., and those of the Rio de la Plata on the S.; its greatest height is 3500 feet above the sea; its western part, the Sierra Parecis, is merely a succession of detached hills. This chain, the coast-chain of Venezuela, and the mountains of Parima, are the only ranges in the continent of America that do not entirely, or in some degree, lie in a meridional direction.

Forests of magnificent trees, bound together by tangled creeping and parasitical plants, clothe the declivities of the mountains and line the banks of the Brazilian rivers, where the soil is rich and the verdure brilliant. Many of the plains on the table-land bear a coarse nutritious grass after the rains only, others forests of dwarf trees; but vast undulating tracts are always verdant with excellent pasture intermixed with fields of corn. Some parts consist of bare sand and rolled quartz; and the Campos Parecis, N. of the Sierra dos Vertentes, in the province of Matto Grosso, is a sandy desert of unknown extent, similar, but upon a smaller scale, to the Great Gobi on the table-land of Tibet.

CHAPTER X.

SOUTH AMERICA.

§ 1. Low lands of South America; desert of Patagonia; Pampas of Buenos Ayres. § 2. The forest of the Amazon. § 3. Llanos of the Orinoco and Venezuela. § 4. Geological notice.

§ 1. THE southern plains are the most barren of the three great tracts of American low lands: they stretch from Tierra del Fuego over 27 degrees of latitude, or 1900 miles, nearly to Tucuman, and the hilly country of Brazil. Palms grow at one extremity, deep snow covers the other many months in the year. This enormous plain, of 1,620,000 square miles, begins on the eastern side of Tierra del Fuego, where it is a flat covered with trees, and therefore superior to its continuation on the continent through eastern Patagonia, which, for 800 miles from the land's end to beyond the Rio Colorado, is a desert of shingle.[1] It is occasionally diversified by huge boulders, tufts of brown grass, low bushes armed with thorns, salt lakes, with saline incrustations as white as snow, and by black basaltic platforms like plains of iron, at the foot of the Andes, barren as the rest. Eastern Patagonia, however, is not one universal flat, but a succession of shingly horizontal plains at higher and higher levels, separated by long lines of escarpments, the gable-ends of the tiers or plains. The ascent is small, for even at the foot of the Andes the highest of these platforms is only 3000 feet above the ocean. The plains are here and there intersected by a ravine or a stream, the waters of which do not fertilize the blighted soil. The transition from intense heat to intense cold is rapid, and piercing winds often rush in hurricanes over these deserts, shunned even by the Indian, except when he crosses them to visit the tombs of his fathers. The shingle ends a few miles to the N. of the Rio Colorado: there the red calcareous earth of the Pampas begins, covered with coarse tufted grass, without a tree or bush to relieve the view. This country, nearly as level as the sea and without a stone, extends almost to the table-land of Brazil; and for 1000 miles between the Atlantic and the Andes, interrupted only at considerable distances by a solitary umbú, the only tree of this soil, rising like a great landmark. This wide space, though almost destitute of water, is not all of the same description. In the Pampas of Buenos Ayres there are four distinct regions. For 180 miles W. from Buenos Ayres the plains are covered with thistles and lucern of the most vivid green so long as the moisture from the rain lasts. In spring the verdure fades, and a month afterwards the thistles shoot up 10 feet high, so dense and so protected by spines that they are impenetrable. During the summer the dried stalks are broken by the wind, and the lucern again spreads freshness over the ground. The Pampas, for 430 miles W. of this region, are covered with long tufted luxuriant grass, intermixed with flowers, affording inexhaustible pasture to thousands of horses and cattle. This is followed by a tract of swamps and bogs, to which succeeds a region of ravines and stones; and, lastly, a zone, reaching to the Andes, of thorny bushes and dwarf trees forming a dense thicket. The plains in Entre Rios in Uruguay, those of Santa Fé, and a great part of Cordova and Tucuman, are of sward, with cattle farms. The banks of the Paraná, and other tributaries of the Plata, are adorned with an infinite variety of tropical productions, especially the graceful tribe of palms; and the river islands are bright with orange-groves. A desert of sand, called El Gran Chaco, exists W. of the Paraguay, the vegetable produce of which is confined to varieties of the aloe and cactus tribes. Adjoining this desert are the Bolivian provinces of Chiquitos and Moxos, covered with forests and jungles, the scene of the most laborious and beneficent exertions of the Jesuit missionaries in the last century towards the civilization of the aborigines of South America.

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[1] Admiral P. B. King and Mr. Darwin.

The Pampas of Buenos Ayres, 1000 feet above the sea, sink to a low level along the foot of the Andes, where the streams from the mountains collect in large lakes, swamps, lagoons of great extent, and wide-spreading salt-marshes. These swamps are swollen to thousands of square miles by the annual floods of the rivers, which also inundate the Pampas, leaving a fertilizing coat of mud. Multitudes of animals perish in the floods, and the drought that sometimes succeeds is more fatal. Between the years 1830 and 1832 two millions of cattle died from want of food. Millions of animals are sometimes destroyed by casual and dreadful conflagrations in these countries when covered with dry grass and thistles.[1]

§ 2. The great forest, or Matto, as it is called by the Brazilians, bordering on the river Amazon forms the second division of the

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[1] Sir Woodbine Parish on Buenos Ayres, and Sir Francis Head's Journey over the Pampas.

South American low lands. This country is more uneven than the Pampas, and the vegetation is so dense that it can only be penetrated by sailing up the river or its tributaries. The forests not only cover the basin of the Amazon from the Cordillera of Chiquitos to the mountains of Parima, but also its limiting mountain-chains, the Sierra dos Vertentes and Parima, so that the whole forms an area of woodland more than six times the size of France, lying between the 18th parallel of S. latitude and the 7th of N.; consequently intertropical and traversed by the equator. There are some marshy savannahs along the margins of the Lower Amazon, and some grassy steppes on the Guiana side of the river; but they are insignificant compared with the virgin forest, which extends 1500 miles in length, varying in breadth from 350 to 800 miles. According to Humboldt, the soil, enriched for ages by the spoils of the forest, consists of the richest mould. The temperature in the deep and dark recesses of these primeval woods is much moderated by the shade and cool winds from the sea; but the air is saturated with moisture, and the damp is so excessive that a blue mist rises in the early morning among the huge stems of the trees, and envelopes the entangled creepers stretching from bough to bough. A death-like stillness prevails during the heat of mid-day, but at sunrise and sometimes in the night, the songs of strange birds, and the cries of invisible animals, give some degree of animation to the leafy wilderness. The anxiety and terror of the animals before a thunderstorm is excessive, and all nature seems to partake in the dread. The tops of the lofty trees rustle ominously, though not a breath of air agitates them; a hollow whistling in the high regions of the atmosphere comes as a warning from the black floating vapour; midnight darkness envelopes the ancient forests, which soon after groan and creak with the blast of the hurricane. The gloom is rendered still more hideous by the vivid lightning and the stunning crash of thunder. Even fishes are affected with the general consternation; for in a few minutes the Amazon rages in waves like a stormy sea.

§ 3. The Llanos of the Orinoco and Venezuela, covered with long grass, form the third region of South American low lands, and occupy 153,000 square miles between the deltas of the Orinoco and the coast range of Venezuela, level as the surface of the sea. It is possible to travel over these flat plains for several hundred miles without seeing an eminence a foot high. They are twice as long as they are broad; and as the wind blows constantly from the E., the climate is the more ardent the farther W. These steppes for the most part are destitute of trees or bushes, yet in some places they are dotted with the mauritia and other palm-trees. Flat as these plains are, there are in some places two kinds of inequalities;

one consists of banks or shoals of grit or compact limestone, 5 or 6 feet high, perfectly level for several leagues, and imperceptible except on their edges: the other inequality can only be detected by levelling instruments; it is called a Mesa, and is an eminence rising imperceptibly to the height of some fathoms. Small as the elevation is, a mesa forms the watershed from S.W. to N.E., between the affluents of the Orinoco and the streams flowing to the northern coast of Terra Firma. In the wet season, from April to the end of October, the tropical rains pour down in torrents, and hundreds of square miles of the Llanos are inundated by the floods of the rivers. The water is sometimes several feet deep in the hollows, in which so many horses and other animals perish that the ground retains the smell of musk, an odour peculiar to many South American quadrupeds. From the flatness of the country too, the waters of some affluents of the Orinoco are driven backwards by the floods of that river, especially when aided by the wind, and form temporary lakes. When the waters subside, these steppes, manured by the sediment, are mantled with verdure, and produce the pine-apple plant, whilst occasional groups of fan-palm trees and mimosas skirt the rivers. When the dry weather returns, the grass is burnt up; the air is filled with dust raised by currents occasioned by difference of temperature, even where there is no wind. If by any accident a spark of fire falls on the scorched plains, a conflagration spreads from river to river, destroying every living creature, and leaves the clayey soil sterile for years till vicissitudes of weather recrumble the brick-like surface into a vegetable-producing earth.

The Llanos lie between the equator and the Tropic of Cancer; the mean annual temperature is about 84° of Fahrenheit. The heat is most intense during the rainy season, when tremendous thunder-storms are of common occurrence.

§ 4. The most remarkable circumstance in the geological features of the South American continent is the vast development of volcanic action, which is confined to the chain of the Andes, where it has acquired a considerable breadth, as in the Peru-Bolivian portion, in the part nearest the sea-coast. It would be wrong, however, to say that there are no traces of modern volcanic action at a great distance from the sea.[1] The volcanic vents occur in the Andes in linear groups: the most southern of these is that of Chile, extending from the latitude of Chiloe to that of Santiago, 42° to 33° S.: in this space exist five well authenticated craters in ignition—the most southern is the volcano of Llanquihue or Osorno, observed by M. Gay, and the most northern that of Maypu, the fires of which are sometimes seen from the capital of Chile. Between these two are situated those of Villarica, Antuco, and Chillan. The volcano of Antuco was, in 1845, when visited by M. Domeyko, in great activity; its height, as determined by that naturalist, is 8918 feet only, and the snow-line on its sides 7996 feet above the sea; the volcano of Villarica is 120 miles S., and that of Chillan 80 miles N. of the volcano of Antuco. From the 33rd parallel to the Bolivian frontier there does not appear to be a single volcanic vent, but in the province of Atacama rise the volcanoes of Licancan and Atacama, E. of San Pedro of Atacama, still occasionally in activity. The mountain of Isluga, in lat. 19° 11′ S., and in the province of Tarapaca, is also an active volcano; but the great centre of volcanic action in this part of the Western Cordillera extends from 18° 10′ S., to 16° 20′ S., where the Andes have changed their direction from being parallel to the meridian to one inclined nearly 45 degrees to that line. The trachytic giant domes of the Andes, Sahama, and the Nevado of Chuquibamba mark the N. and S. limits of this line of vents: the former, one of the most perfect trachytic pyramids in the Andes, rises to the height of 22,350 feet, in lat. 18° 7′ S. and long. 68° 54′ W.; near to it are the twin Nevados of Pomarape and Parinacota, one of which appeared to Mr. Pentland still to emit vapours. The group of snowy peaks seen from Arica, the centre of which, the Nevado of Tacora, is in lat. 17° 43′ S., offers a broken-down crater, and an active solfatara, on one of its sides. This region was the focus of the great earthquake of August 13th, 1868. Between the latitude of Arequipa (16° 24′ S.) and the equatorial group of volcanoes, the Andes do not present a single active crater. This equatorial group extends over a meridional line of 3½ degrees—between the Peak of Sangay and the volcano of Los Pastos. The most remarkable of these volcanic vents are the Sangay, Tunguragua, and Cotopaxi, all situated in the Cordillera most remote from the ocean. Pichincha was in activity as recently as 1831; and N. of the equator, Imbabura, the volcanoes of Chiles, of Cumbal, of Tuquercs or Los Pastos,

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[1] Mr. Pentland found a very perfect volcanic crater, with well-marked currents of lava issuing from it—a rare occurrence in the higher craters of the Andes—not far from San Pedro de Cacha in the valley of the Yucay (lat. 14° 12′ S., long. 71° 15′ W., and at an elevation of 12,000 feet), near to the ruins of the Temple of the Inca Viracocha, a monument and a locality celebrated in Peruvian legend, the nearest point of the sea-coast being 175 miles distant. It is probable that some of the most celebrated mining districts of Alto Peru—Potosi, for instance, situated in porphyry—have been

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upheaved at a very recent period. Modern volcanic rocks are not wanting in the valley of the Desaguadero; volcanic conglomerates exist in the deep ravines round the city of La Paz, lat. 16° 39′ S.; and the mountain of Litanias, which furnishes the building-stone for that Bolivian city (lat. 16° 42′ S., long. 68° 19½′ W.), is composed of a most perfect trachyte, and rises to a height of 14,500 feet above and at a distance of 160 miles from the Pacific.

of Sotara and Purace, mark the extension of actual volcanic action into the northern hemisphere.

Granite, which seems to be the base of the whole continent, is widely spread to the E. and S.; it appears in Tierra del Fuego and in the Patagonian Andes abundantly, at great elevations, and in Chile and southern Peru forms the line of hills parallel to the Pacific, wherein are situated the mineral riches of the former republic. Palæozoic rocks abound in the Bolivian Cordillera, the lofty mountains according to Dr. Forbes showing uptilted strata of the Silurian epoch; and the carboniferous limestone, with its characteristic fossils, forms in the basin of Titicaca entire islands, amongst others that from which the lake takes its name, one of the earliest seats of Peruvian civilization. Quartz rock, probably of the Devonian period, is much developed; generally mixed with mica, and rich in gold and specular iron. It sometimes extends several leagues in the western declivities of Peru 6000 feet thick.

Fossil shells of different geological periods are found at various elevations, which shows that many upheavings and subsidences have taken place in the chain of the Andes. Mr. Pentland found shells of the Silurian period at a height of 17,500 feet on the Bolivian Nevado of Antakäua, lat. 16° 21′ S., and those of the carboniferous limestones as high as 14,200 in several parts of Upper Peru. Mr. Darwin supposes that the whole range, after twice subsiding some thousand feet, was brought up by a slow movement in mass during the Eocene period, after which it sank down once more several hundred feet, to be again uplifted to its present level by a slow and often interrupted motion. These vicissitudes are very perceptible, especially at its southern extremity. Stems of large trees, which Mr. Darwin found in a fossil state in the Uspallata range, on the eastern declivity of the Chilian Andes, now 700 miles distant from the Atlantic, exhibit a remarkable example of such vicissitudes. These trees, with the volcanic soil on which they had grown, had sunk from the beach to the bottom of a deep ocean, from which, after five alternations of sedimentary deposits and deluges of submarine lava of prodigious thickness, the whole mass was raised up, and now forms the Uspallata chain. Subsequently, by the wearing of streams, the embedded trunks have been brought into view in a silicified state, projecting from the soil in which they grew—now solid rock.

"Vast and scarcely comprehensible as such changes must ever appear, yet they have all occurred within a period recent when compared with the history of the Cordillera; and the Cordillera itself is absolutely modern compared with many of the fossiliferous strata of Europe and America."[1]

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[1] Darwin's Journal of Travels in South America.

From the quantity of shingle and sand in the valleys in the lower ridges, as well as at latitudes from 7000 to 9000 feet above the present level of the sea, it appears that the whole area of the Chilian Andes has been upheaved by a gradual motion; the coast is now rising in some places by the same imperceptible degrees; it has been sometimes suddenly elevated by small upheavings of a few feet, accompanied by earthquakes, one of the most remarkable of which was that which shook the continent to an extent of 1000 miles on the 20th February, 1835.

On the eastern side of the Andes the continent from Tierra del Fuego to the Rio de la Plata appears to have been raised *en masse* by one great elevating force, acting equally and imperceptibly for 2000 miles, within the period of the now living race of marine animals, which, imbedded in many parts of these plains, still retain even their colours. The gradual upward movement was interrupted by at least eight long periods of repose, marked by the edges of the successive plains, which, extending from S. to N., had formed so many lines of sea-coast, as they rose higher and higher between the Atlantic and the Andes. It appears, from the shingle and fossil shells found on both sides of the Cordillera, that the whole south-western extremity of the continent, and indeed the whole Andean chain, has been rising slowly for a long time. The rise on some parts of the coast of Chile has been at the rate of several feet in a century; but it has diminished eastward, till, in the Patagonian plains and Pampas, it has been only a few inches in the same time.

The instability of the southern part of the American continent is less astonishing when it is considered that at the time of the great earthquake of 1835 the volcanoes in the Chilian Andes were in eruption contemporaneously for 720 miles in one direction and 400 in another, so that in all probability there was a subterranean lake of molten lava twice as large as the Black Sea below this extremity of the continent.[1]

The terraced plains of Patagonia, which extend for hundreds of miles along the coast, are of tertiary strata, not in basins, but in one great deposit, above which lies a thick stratum of a white pumiceous substance, extending at least 500 miles, a tenth part of which consists of marine infusoria. Over the whole lies the shingle already mentioned, spread along the coast for 700 miles in length, with a mean breadth of 200 miles, and 50 feet thick. These myriads of pebbles, chiefly of porphyry, have been torn from the rocks of the Andes, and water-worn, at a period subsequent to the deposition of the tertiary strata. All the plains of Tierra del Fuego and Patagonia, on both sides of the Andes, are strewed with huge boulders, probably transported by icebergs which had descended to lower latitudes in ancient times than they do now—observations of great interest, which we owe to Mr. Darwin.

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[1] Darwin's Journal of Travels in South America.

The stunted vegetation of these sterile plains was sufficient to nourish several large species of animals, now extinct, even at a period when the species now living in the Patagonian seas existed.

CHAPTER XI.

CENTRAL AMERICA.

§ 1. General configuration of Central America. § 2. Table-land of Guatemala. § 3. The coast region. § 4. Proposed ship-canal between the Atlantic and Pacific. § 5. West Indian islands. § 6. Geological notice.

§ 1. TAKING the natural divisions of the continent alone into consideration, Central America may be regarded as lying between the Isthmus of Panamá and Darien and that of Tehuantepec, and consequently within the tropical zone. This narrow tortuous strip of land, which unites the continents of North and South America, stretches from S.E. to N.W. about 1200 miles, varying in breadth from 30 to 300 or 400.

As a regular chain the Andes end suddenly at the Isthmus of Panamá, but as a mass of high land they continue through Central America and Mexico, in an irregular mass of table-lands and mountain ranges. The high land which forms the central ridge and the watershed between the two oceans is very steep on its western side, and runs near the coast of the Pacific, where Central America is narrow; but to the north, where it becomes wider, it recedes to a greater distance from the shore than the Andes do in any other part between Cape Horn and Mexico. From the survey for the railway across the Isthmus of Panamá, the highest point traversed by the road is Baldwin's Summit, 299 feet above the sea —which it crosses by a tunnel, 254 feet above the same level.

This country consists of three distinct groups, divided by valleys which run from sea to sea, namely, Costarica, the group of Honduras and Nicaragua, and the group of Guatemala.[1]

North of the isthmus the plains of Panamá, very little raised above the sea, and in some parts studded with hills, follow the direction of the isthmus for 280 miles, and end at the Bay of Parida. From thence proceeds the forest-covered Cordillera of Veragua, supposed to be 9000 feet high, but united with the Cordillera of Salamanca, on the western side of which is the gold-mine of Tisingal, celebrated by the early historians of the Conquest; the latter

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[1] Johnston's Physical Atlas.

Cordillera extends to the elevated table-land of Costarica, surrounded by volcanoes, and terminates at the plain of Nicaragua, which, together with its lake, occupies an area of 30,000 square miles, and forms the second break in the great Andean chain. The lake is only 125¼ feet above the Pacific, from which it is separated by a line of active volcanoes. The river of San Juan flows from its south-eastern end into the Carribbean Sea, and at its northern extremity it is connected with the smaller lake of Managua or Leon by the river Panaloya or Tipitapa. By this water-line it has been projected to unite the two seas, the distance between them being only 20 miles. The high land recommences, after an interval of 170 miles, with the Mosquito country and Honduras, which mostly consist of table-lands and high mountains, some of which are active volcanoes. From a recent survey it appears that there is a perfectly practicable route across Honduras through the valleys of the rivers Humaya and Goascoran, for a railway only 220 miles long, which would connect Port Cortez on the Atlantic with Fonseca on the Pacific, both first-rate harbours: a combination so favourable does not exist throughout all Central America for an inter-oceanic intercourse.

§ 2. Guatemala is a table-land intersected by deep valleys, which lies between the plain of Comayagua and the Isthmus of Tehuantepec. It spreads to the east in the peninsula of Yucatan, which terminates at Cape Catoche, and encompasses the Bay of Honduras with terraces of high mountains. The table-land of Guatemala consists of undulating verdant plains of great extent, of the absolute height of 5000 feet, fragrant with flowers. In the S. the cities of Old and New Guatemala are situate, 24 miles apart. The portion of the plain on which New Guatemala stands is bounded on one side by the three volcanoes of Pacaya, del Fuego, and del Agua; which, rising from 7000 to 15,000 feet above the plain, lie 20 miles from the new city on the S.W., and form a scene of great boldness and beauty. The Volcano del Agua, at the foot of which Old Guatemala stands, is a perfect cone, verdant to its summit, occasionally pouring forth torrents of boiling water and stones; it is the highest peak in Central America, rising to 15,000 feet. The old city has been twice destroyed by it, and is now nearly deserted on account of earthquakes. The Volcano del Fuego generally emits vapours from one of its peaks; and the Volcano de Pacaya is only occasionally active. The wide grassy plains are cut by deep valleys to the N., where the high land of Guatemala ends in parallel ridges of mountains called the Cerro Pelado, which run from E. to W. along the 94th western meridian, filling half the Isthmus of Tehuantepec, and unite the table-land of Guatemala with that of Mexico.

Though there are large savannahs on the high plains of Guatemala, there are also magnificent primeval forests, as the name of the country implies, Guatemala signifying, in the native language, a place covered with trees. The banks of the river Papian, or Usumasinta, a tributary of which rises in the alpine lake of Peten, and flows over the table-land to the Gulf of Mexico, are beautiful beyond description.

§ 3. The flat region bordering the coast of Central America is generally narrow, and in some places the mountains and high lands come close to the water's edge. The sugar-cane is indigenous, and on the low lands on the eastern coast all the ordinary productions of the West Indian islands are raised, besides several that are peculiar to the country.

As the climate is cool on the high lands, the vegetation of the temperate zone is there very luxuriant. On the low lands, as in other countries where heat and moisture are in excess, and where nature is for the most part undisturbed, vegetation is vigorous to rankness: forests of gigantic trees seek the pure air above an impenetrable undergrowth, the rivers empty themselves into the sea amidst dense masses of jungle with mangroves and reeds 100 feet high, whilst delightful savannahs vary the scene, and wooded mountains dip into the water.

Nearly the whole coast of the Pacific is skirted by an alluvial plain, of inconsiderable width, and generally very different in character from that on the Atlantic side. In a line along the western side of the table-land there is a continued succession of volcanic mountains, at various distances from the shore, and at various heights, on the declivity towards the Pacific. It seems as if a great crack or fissure had been produced in the earth's surface, along the junction of the mountains and the shore, through which the internal fires had found a vent. There are more than twenty active volcanoes between the 10th and 20th parallels of N. latitude; some higher than the mountains of the central ridge, and several subject to violent eruptions. Altogether there are 38 in Central America, seventeen of which are in Guatemala—a greater number than in any other country, Java excepted.

§ 4. In this age of gigantic enterprise it is truly astonishing that there should be any hesitation about joining two oceans by a short canal of only 40 miles; as if modern engineers, aided by the wealth of two of the richest nations in the world, and possessing all the enterprise of the Anglo-Saxon race, could not overcome every difficulty. Instead of the long and stormy voyages round the Cape of Good Hope and Cape Horn, a ship-canal joining the Atlantic to the Pacific would open a direct line of communication for all the maritime powers of Europe and the United States, not to the western coast of the American continent alone, but to China, Australia, and even India, by which the hurricane region would be avoided and the passages made through a comparatively safe and calm sea.

Six different lines across Central America have been proposed as suited for the purpose, but that by the Isthmus of Darien seems to possess advantages over the others, confirming the opinion given more than 50 years ago, and maintained to the last by the greatest of modern travellers and geographers, Humboldt. It possesses the principal requisites for such an undertaking—a short distance of only 40 miles between the tidal limits of rivers flowing into the two oceans, even allowing one-third for the possible windings of a canal, and a good harbour at both ends. In the latter point it is superior to the Panamá line, which has the indisputable advantage of the greatest depression in the mountains. The line which attracted so much attention a few years ago between the river Savana and Caledonia Bay presents an obstacle in the great height of the mountain ridges near the Atlantic side. But a route farther S., explored by M. de Puydt in 1865, seems to be clear of this obstacle; a depression in the range having been found near the head waters of the river Tanela, N. of the delta of the Atrato and not far distant from the navigable part of the river Tuyra, which disembogues in the Gulf of San Miguel, where there are high tides, and where docks of any magnitude could be formed.

This line passes near the very country of romance. It was from Caledonia harbour that Nuñez de Balboa crossed to the South Sea, and that the earliest expedition was sent by the Spaniards to Peru. Here were the gold-mines of Tisingal, which gave the name of Costa Rica to the shores of the Pacific, the true El Dorado, to which Sir Walter Raleigh and Sir Francis Drake were sent. The harbour still bears the name of the unfortunate colony from Scotland; and the country in which it is situated, known as the "Spanish Main," was celebrated for the lawless but romantic adventures of the Buccaneers. The coast of the Pacific here is rich to exuberance; two crops may be raised in the year; forests of the coco-nut palm extend for miles; it produces the cacao-bean, vanilla, India-rubber, Palo de Vaca, the Tonquin-bean, Chiraqui incense, numerous dye-woods, balsams, medicinal plants, and all the usual productions of a tropical climate. But the vegetation is so rank, the high trees so interlaced with creepers, that the light is shut out; the heat is so intense, and rain so frequent, that the climate is exceedingly unhealthy; and although it would be of no consequence to a steamer passing rapidly through 40 miles, yet it would be a serious difficulty during the construction, which might, however, be overcome by employing the free labour of negroes, who are accustomed to hot and damp climates. In the mean time the Panamá railway conveys goods and passengers to and from the golden lands of California and British Columbia.[1]

§ 5. The West Indian Islands, which are separated from both continents by a deep sea, consist of three distinct groups, namely, the Lesser Antilles or Caribbean Islands, the Greater Antilles, and the Bahama or Lucay Islands. Some of the Lesser Antilles are flat, but their general character is bold, with an insulated peak or a group of mountains in the centre, which slopes to the sea all round, more precipitously on the eastern side, which is exposed to the force of the Atlantic current. Trinidad is the most southerly of a chain of magnificent islands, which, forming a semi-circle, enclose the Caribbean Sea, with its convexity facing the E.. The range is single as far as Guadaloupe, where it splits into two. Trinidad, Tobago, St. Lucia, and Dominica are particularly mountainous, and their mountains are cut into deep narrow ravines, or gulleys, covered by primeval forests. The volcanic islands, which are mostly in the undivided part of the chain, have conical peaks bristled with rocks of a still more rugged form ; but almost all the islands of the Lesser Antilles have a large portion of excellent vegetable soil in a high state of cultivation. Most of them are surrounded by coral reefs, which render navigation dangerous, and there is little intercourse between these islands, and still less with the Greater Antilles, on account of the prevailing winds and currents, which make the return voyage, except by steam, difficult. The Lesser Antilles terminate in the group of the Virgin Islands, which are small and flat, some only a few feet above the sea, and most of them consisting of mere rocks of coral.

The four islands which form the group of the Greater Antilles are the largest and most important in the archipelago. Porto Rico, Haiti or San Domingo, and Jamaica, separated from the Virgin Islands by a narrow channel, lie in a line parallel to the coast-chain of Venezuela, from E. to W. ; while Cuba, by a serpentine bend, separates the Caribbean Sea, or Sea of the Antilles, from the Gulf of Mexico. Porto Rico is 110 miles long and 40 broad, with wooded mountains passing through its centre, nearly from E. to W., which furnish abundance of water. There are extensive savannahs in the interior, and very rich soil on the northern coast, but the climate near the sea is unhealthy.

Haiti or San Domingo, 400 miles long and 60 to 160 broad, has a chain of mountains in its centre, extending from E. to W. like all the mountains in the Greater Antilles, the highest point of which is 9000 feet above the sea. A branch diverges from the main stem to Cape Tiburon, so that Haiti contains a great proportion of high land. The mountains are susceptible of cultivation nearly to the summit, and are clothed with undisturbed tropical forests. The extensive plains are well watered, and the soil, though not deep, is productive.

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[1] Admiral Fitzroy on the Great Isthmus of Central America, in Geographical Journal, vol. xx. M. de Puydt, ibid. vol. xxxviii.

Jamaica, the most valuable of the British possessions in the West Indies, has an area of 4256 square miles, of which 110,000 acres are cultivated, chiefly as sugar-plantations. The principal chain of the Blue Mountains lies in the centre of the island, from E. to W., with so sharp a crest that in some places it is only 4 yards across. Offsets from it cover all the eastern part of the island. The more elevated ridges are flanked by lower ranges, descending to verdant savannahs. The escarpments are wild, the declivities steep, and mingled with stately forests. The valleys are very narrow, and not more than a twentieth part of the island is level ground. There are many small rivers, and the coast-line is 500 miles long, with at least 30 good harbours. The mean summer-heat is 80° of Fahrenheit, and that of winter is 75°. The plains are often unhealthy, but the air in the mountains is salubrious; fever has never prevailed at the elevation of 2500 feet.

Cuba, the largest island in the Colombian Archipelago, has an area of 3615 square leagues and 200 miles of coast, but so beset with coral reefs, sandbanks, and rocks, that only a third of it is accessible. Its mountains, which attain the height of 8000 feet, occupy the centre, and fill the eastern part of the island, in a great longitudinal line. No island in these seas is more important with regard to situation and natural productions; and although much of the low ground is swampy and unhealthy, there are vast savannahs, and about a seventh part of the island is cultivated.

The Bahama Islands are the least valuable and least interesting part of the archipelago. The group consists of about 500 islands, many of them mere rocks, lying E. of Cuba and the coast of Florida. Twelve are larger, and cultivated; producing log-wood and mahogany. The most intricate labyrinth of shoals and reefs, chiefly of corals, madrepores, and sand, encircle these islands; some of them rise to the surface, and are adorned with groves of palm-trees. Watling's Island, in latitude 24° N., is the first part of the New World on which Columbus landed — the next was Haiti, where his ashes rest.

§ 6. The geology of Central America is little known; nevertheless it appears, from the confused mixture of table-lands and mountain-chains in all directions, that the subterraneous forces must have acted more partially and irregularly than either in South or North America. In the West Indian Archipelago volcanic action is confined to the smaller islands, which, forming a line in a meridional direction, extend from 12° to 18° N., and may be designated as the

Caribbean range; it begins with Grenada and ends with St. Eustatius. St. Vincent, St. Lucia, Martinique, a great portion of Guadaloupe, Montserrat, Nevis, and St. Kitts are volcanic; most of them possess craters recently extinct, which have vomited ashes and lava within historical periods; whilst the less elevated of the smaller Islands, Tobago, Barbadoes, Deseada, Antigua, Barbuda, and St. Bartholomew's, with the Virgin Islands and Bahamas, are composed either of calcareous or coral rocks.

CHAPTER XII.

NORTH AMERICA.

§ 1. **General configuration of the continent; table-land and mountains of Mexico; ancient capital of Mexico; the Barancas. § 2. The Rocky Mountains. § 3. The Great Western Desert plateau. § 4. The mountain system of the Pacific; California; Vancouver Island.**

§ 1. THE continent of North America, including Greenland, has an area of more than eight millions of square miles. It comprises a large central plain, a broad elevated plateau, three great mountain systems, and two long oceanic slopes. The great plain extends N. and S., from the Gulf of Mexico to the Arctic Ocean. It is bounded on the E. by the Appalachian or Alleghany Mountains, and on the W. by the table-lands from which rise the peaks of the Rocky Mountains. "This broad and elevated belt of table-lands and parallel chains is one of the largest mountain-systems of the globe, much exceeding in its solid bulk above the level of the sea even the mighty chain of the South American Andes, being twice as broad and nearly as long."[1]

Commencing from the S., the table-land of Anahuac or Mexico, which, though not the highest, is by far the most extensive plateau on the face of the earth, extends for 1600 miles from its southern extremity at the isthmus of Tehuantepec to the S.W. of New Mexico, a distance equal to that from the N. of Scotland to Gibraltar. From thence it is continued in a series of table-lands and isolated ranges, not absolutely continuous with the Rocky Mountains, for these terminate, according to Dr. Bell, a little to the N.E. of the northern end of the Mexican table-land, but midway between them and the coast ranges, which extend from California to the most northern extremity of the continent. At its southern extremity, where the Mexican table-land is narrow, mountains rise from the isthmus and abut upon it; on the E. the plateau descends so abruptly from a height of 3000 feet that, seen from the shores of the Mexican Gulf, it looks like a chain of mountains, while on the

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[1] Prof. H. D. Rogers.

W. it descends gently to the coast of the Pacific by a series of four longitudinal valleys. On the surface of the plateau groups and ridges of mountains rise; but when not traversed by these elevations the table-land is as level as the ocean, so that a carriage-road of more than a thousand miles from the city of Mexico northward is either over a dead level or gentle undulations.

The capital of Mexico, once the royal residence of Montezuma, must have greatly surpassed the modern city in extent and magnificence, as many of its remains show. It is 7482 feet above the level of the ocean, and surrounded by four plains, of which Tenochtitlan is the most remarkable, being of elliptical form, 55 miles long, and 35 wide, enclosed by ridges of basalt and porphyritic rocks running from S.S.E. to N.N.W. On the south-eastern side, which is the highest, stands the snow-shrouded cone of Orizaba with its ever-fiery crater, seen like a star in the darkness of the night, which has obtained for it the name of Citlaltepetl—"the Mountain of the Star." Popocatepetl, the loftiest mountain in Mexico, 17,720 feet above the ocean, lies farther W., and is in a constant state of eruption, which, with the volcanoes of Iztacihuatl and Toluca, having an absolute altitude of 15,705 and 13,416 feet respectively, form a magnificent volcanic circuit, in the midst of which Mexico and its lake are situated. The volcanic cone of Tuxtla rises in a group of wooded hills near the shores of the Gulf of Mexico, and on the plains of the Malpays, on the western slope of the table-land about 100 miles from the Pacific, is the volcanic cone of Jorullo, which rose suddenly, in the night of the 29th of September, 1756, to the height of 1700 feet above the level of the plain, amidst hundreds of little flaming cones which covered the country from three to four square miles. The great volcano of Colima stands insulated on the plain of that name, also between the western declivity of the table-land and the Pacific.

Deep cavities called Barancas are a characteristic feature of the table-land of Mexico: they are large rents two or three miles broad and many more in length, often 1000 feet deep, with a brook flowing through them. Their sides are precipitous and rugged, with overhanging rocks covered with trees. Vegetation varies with the elevation, consequently the exuberance which adorns the coasts of the gulf vanishes on the high plain, which, although producing much grain and pasture, is often saline, sterile, and treeless, except in some places where oak-trees grow to an enormous size.

The Mexican table-land maintains a very great absolute altitude to the N., where the plateau of Sonora forms its continuation, and overhangs the Gulf of California from the 25th to the 32nd parallel of N. latitude. Near Guanaxuato the breadth is about 100 miles. The western chain is the Sierra Madre, which contains the richest silver mines in the world; it goes through Zacatecas and W. of Chihuahua, then it runs due N. under the names of Sierra de Acha and Sierra Verde. The eastern chain is that of Cohahuela and Potosi, which lifts itself out of the western edge of the great central plain like a huge colossal wall deeply indented and gashed in its steep flank, with vast mountain buttresses jutting forward into the plateau of the American desert.

§ 2. In the southern part of Colorado, the Rocky Mountain plateau retains the name of the Sierra Madre; and here it has an average elevation of 12,000 feet and a breadth of 300 miles. Elevated valleys of great size and beauty, in which the rivers flowing E. and W. take their rise, occur on both slopes of the Sierra Madre. In Colorado Territory four of these parks exist—the North, Middle, South, and San Luis Parks—each about 9400 square miles in extent, elliptical in form, and surrounded by mountains which reach the limit of perpetual snow. The elevation of these parks is from 6000 to 6400 feet. They are separated from each other by vast sweeps of the Cordillera from E. to W. The mountain-sides are clothed with pine, spruce, fir, and aspen, and fine grassy meadows abound in the lower grounds.

The fertile plain of Santa Fé and Rio Grande del Norte, 50 miles broad at its northern extremity, is situated in a depression of the Rocky Mountain plateaus. There is a break in the mountain-chains at the northern end of the Sierra Verde for 8 miles, so that the plain of the table-land, itself 9000 feet above the level of the sea, becomes the watershed of the Colorado of California on one hand, and of the rivers which run into the Gulf of Mexico on the other. Through the passes of this region the railway which unites the two oceans has been carried. The pass of Kutanie is in 48½° N. lat., so it lies within the British territory, but a railway could only be made to pass through it by tunnels many miles long, whereas the Vermilion pass, which is a deep gorge N. of the lofty group of mountains that rise 16,000 feet, is only 5000 feet above the level of the sea, which is 1000 feet less than any known pass over the Rocky Mountains, and is 4000 feet lower than the water-shed of the Colorado and the Mexican Gulf mentioned above.

North of this break the Rocky Mountains separate into three chains, and become very complicated. Between the river Arkansas and the N. fork of the Platte there are peaks which rise to 10,000 and 12,000 feet, " but the Wind River Mountains are the highest of that chain, where Fremont's Peak has an elevation of 13,570 feet. This great range is the axis or central watershed of the whole continent; the head-streams of the Missouri flow from its eastern flank, and those of the Colombia and Rio Colorado, which go to the

Pacific, from its western." More to the N., in the eastern or principal chain, and near the sources of the Saskatchewan, are Mount Hooker, Mount Brown, and Mount Murchison, which rise to 15,700, 16,000, and 15,789 feet respectively. The mountains now decrease in height; N. of the 58th parallel they are only 4000 feet above the sea, and about 3000 in 62° N. lat.

§ 3. The table-land of Anahuac is continued to the N. by the plateau of Sonora, in which are many fertile valleys. To it succeeds the Great Western Desert plateau, a wide elevated desert belt stretching from the Gulf of California to the Arctic Ocean, having a mean elevation of 5000 feet above the level of the sea, and spreading over 13° of longitude between the parallels of 35° and 45°. It consists of three great regions or basins. The most southerly is the basin of the Colorado at the head of the Gulf of California, a region of mountain-ridges and table-lands which slope gently to the west and to the Gulf; this basin has an area of 200,000 square miles, or nearly as large as France. Except the alluvial flats along the lower course of the Colorado, the country consists of a succession of arid and barren terraced plateaus, through which the main river and its tributaries have scooped narrow ravines or cañons of prodigious depth. The grand cañon of the Colorado is 500 miles in length and from 2000 to 5000 feet in depth. Thus the streams of the region, instead of flowing near the surface and irrigating the country, are lost in the bowels of the earth, leaving the uplands to everlasting sterility. The second great natural division is the central basin or Great Salt Desert of Utah, having an area of 280,000 square miles. This is an enclosed continental river-basin, consisting of vast elevated desert steppes from 4000 to 5000 feet above the sea, many of these arid plains being covered with incrustations of salt, and divided by mountain-ridges trending N. and S. It is a dry, rainless region, because the prevailing winds come from the Atlantic on one side, and the Pacific on the other; the former are deprived of their moisture while blowing over the continent and Rocky Mountains, while the vapour brought from the Pacific by the west winds is precipitated on the tops of the lofty coast-chains, so that both arrive as dry winds at the desert, which is consequently doomed to perpetual barrenness, at least till some great geological change takes place. The desert has therefore few streams, the Humboldt is the greatest yet known; but it has innumerable lakes, which, having no outlet, are naturally salt, because whatever streams fall into them continually bring salt from the soil around, and, as in that latitude the evaporation is very great, the water goes off and the salt remains, and has increased so much in some of the lakes, as for example the Great Salt Lake, that it is charged with common salt almost to saturation. That lake, the Utah and Nicollet lakes, are best known; but there is a long line of them, probably less salt, at the eastern foot of the Sierra Nevada.

In the third natural division the Desert plateau becomes much contracted in width towards the 50th parallel of N. latitude, and extends along the western side of the Rocky Mountains northward through half the continent, sloping gently to the W. and to the Arctic Ocean. It contains the basins of Frazer and Simpson Rivers, and the affluents of the Oregon or Colombia. "All these rivers flow to the Pacific through the Cascade Range. Still farther to the N.W., beyond the sources of the M'Kenzie River, the long belt is longitudinally drained by the Yukon, which reaches the sea in Norton Sound of Behring Strait." "The whole of this long belt of country has an undulating surface of fertile valleys and tablelands, but in the basin of the Oregon high rugged volcanic plains are found. It has a mild climate, many lakes, and feeds some of the greatest rivers."

§ 4. The mountain-system of the Pacific, which bounds the great desert-zone on the W., maintains a general parallelism to the eastern or proper chain of the Rocky Mountains, and ranges from the peninsula of California through the whole distance to Alaska Territory. It is a wide, complex, and very elevated chain of mountains, its main central crests and loftiest peaks surpassing those of the Rocky Mountains in altitude. In lower or peninsular California, where it bears the name of Sierra de Lucia, it is a single ridge; but in lat. 35° it divides into two branches trending northwards, namely the Coast-Mountains of California and Oregon, and the Sierra Nevada; between these lies the gold-producing valley of California. The Coast-Mountains run close to the Pacific, W. of the valleys of Sacramento and Wahlahmath, and extend in a broken chain to Vancouver Island; while the Sierra Nevada, the great watershed which insulates the enclosed and elevated plateau of Utah from the golden basin of California, passing the 42nd parallel, is continued in a N.N.-eastern direction by the Cascade Mountains, the loftiest part of the whole range, on which are situated Mount Pitt and Mount Jefferson in Oregon, and Mount Baker on the borders of British Columbia. It takes its name from the number of rapids and waterfalls that traverse it where it crosses the Frazer and Oregon Rivers. Passing these, it goes N.W. to Alaska Territory, where it curves round and extends W. till it ends in the volcanic peninsula of Aliaska. It contains three peaks which are 14,500 feet above the sea, and even more; those of St. Helen's and Mount Regnier are active though rather torpid volcanoes, while Mount Baker, Mount Fairweather, 14,708 feet, and Mount St. Elias, 14,970, the highest points of the chain, are all supposed to be occasionally in eruption.

The Pacific slope is a long but comparatively slender belt between the Great Pacific chain and the ocean. In the peninsula of California it is a narrow tract sloping rather steeply to the sea; but N. of the 34th parallel its average breadth is 100 miles, and it includes the whole continental slope from the Sierra Nevada to the ocean. It consequently comprises the golden valley of California and the Coast-Mountains, of which there are three ridges as far as 42° N. lat. N. to the 60th degree the average width is the same, but increases in breadth from Vancouver Island northwards, and separates again into three mountain-belts, of which the Wahlahmath is the most easterly. The slope is much penetrated by great spurs from the Cascade range and the Pacific Alps on the E., and on the W. by estuaries and straits. In fact, the archipelagoes and islands along the coast have the same bold character as the mainland, and may be regarded as the tops of a submarine chain of table-lands and mountains which constitute the most westerly ridge of the maritime chains. The mountains on the coast of the Pacific and the islands are in many places covered with colossal forests, and many of our beautiful shrubs and plants have been brought from thence, but wide tracts in the S. are sandy deserts.

Vancouver Island has recently risen into much importance on account of its excellent harbours and its deposits of coal. Esquimalt Harbour, in the S.E. of the island, is the best harbour on the N.W. shores of North America. The coal, which is chiefly worked at Nanaimo, is found in seams varying from 2½ to 5 feet in thickness. It is very valuable and largely exported. The sea-board scenery of Vancouver Island is abrupt, with numerous fiord-like harbours, especially on the western coasts, where Alberni, Nootka, Quatsino and other Sounds extend far inland. The interior is elevated. Mount Arrowsmith reaches a height of 5970 feet, the Albert Edward range has an elevation of 6700, and the Crown Mountain of 6000 feet. Through its whole length the island is occupied by a backbone of trap, which shows strongly marked features of glacial action. The country is covered with dense forests of pine, oak, willow, alder, cedar, and maple. Tracts of grass-land are occasionally met with, and lovely lakes and tarns abound.

CHAPTER XIII.

NORTH AMERICA—*continued*.

§ 1. The great central plains, or valley of the Mississippi; cultivation of the district. § 2. British North America; productiveness of Canada; singular appearance of the forests during winter. § 3. Hudson Bay territory; Capt. Palliser's exploration of the Saskatchewan. § 4. The Rocky Mountains. § 5. The Alleghanies; picturesque scenery of the Appalachian Mountains. § 6. Gradual decrease of vegetation towards the Arctic region; islands of the north-east coast; Newfoundland. § 7. The Atlantic plain; cultivation east of the Alleghanies; the United States territory. § 8. Geological notice. § 9. Fossil mammalia. § 10. Mean height of continents.

§ 1. The great central plain of North America, lying between the Rocky and Alleghany Mountains, and reaching from the Gulf of Mexico to the Arctic Ocean, has an area of 3,245,000 square miles, which is 245,000 square miles more than the central plain of South America, and about half the size of the great plain of the old continent, which is less fertile; for although the whole of America is not more than half the size of the old continent, it contains at least as much productive soil. The plain, 3000 miles long, becomes wider towards the N., and has a low table-land which crosses it from Labrador, and along the sources of the Missouri to the northern verge of the Utah Desert. "Stretching at right angles to this, the broad Rocky Mountain zone, which forms the watershed of the continent, may be regarded as the crest of a vast undulation of the surface descending from an elevation of from 4000 to 6000 feet to the level of the sea, with only two intervening swells, those on which the Cordilleras of the Pacific and Alleghanies stand."

Along the whole eastern side of the Rocky Mountains a high plateau extends from the base of the Cohahuela chain to the far N., including the table-lands N. of the Great Slave Lake, and E. of the M'Kenzie river. At its southern extremity it is from 4000 to 5000 feet above the level of the sea; but rises to 6000 between the parallels of 38° and 48°, and maintains a considerable elevation beyond. "From this height the land descends in slopes, but chiefly in bold terraces, to the lower level of the great plain, a structure peculiarly marked between the river Pecos and the Black Hills of Missouri, where the plateau descends in two very bold terraces; the upper one, which is from 200 to 300 miles broad, has an absolute altitude of 5000 feet at the base of the mountains, and at its eastern edge it is 1000 feet above the second steppe. It is a thirsty desert, without tree or shrub, except along the margins of the scanty streams, and at certain seasons is nearly without vegetation. N. of the Missouri it is more grassy, and in the British territories it has many streams and lakes. The Rio Grande and the M'Kenzie flow along this plateau, the one towards the S., and the other towards the N., while the tributaries of the Missouri and Mississippi, and those of the Saskatchewan and Churchill, flow across it. The lower terrace is altogether similar to the upper to the S.; but towards its middle and northern end it has more vegetation, and on the streams thicker belts of trees. All the rivers from the Arkansas to the Pecos, inclusive, descending from the upper steppe or terrace, pass out from between confining precipices often several hundred feet high, through narrow sluices of enormous depth. Along the eastern border of this lower treeless steppe there extends for more than 400 miles a remarkable belt of woodland from 5 to 25 miles wide, called the 'Cross Timbers.' It separates the fertile and well-watered plains of Texas, abounding in verdant prairies and clumps of trees, from the barren naked steppes lying between the Missouri and the Rocky Mountains, which are known as the Great Western American Desert," and which extend for 2° into the British territories.

Most of the cultivation on the right side of the Mississippi is along the Gulf of Mexico and in the adjacent provinces, and is entirely tropical, consisting of sugar-cane, cotton, and indigo. At the mouth of the Mississippi there are marshes which cover 35,000 square miles bearing a rank vegetation, and its delta is a labyrinth of streams and lakes, with dense brushwood, the very home of the crocodile. Salt rocks and saline grounds occur occasionally in the prairies, as the Grand Saline between the rivers Arkansas and Neseikelongo, which is often covered 2 or 3 inches deep with salt, like a fall of snow; the wild cattle come in multitudes to these places to lick the salt, of which they are very fond. Prairies, so characteristic of the North American continent, lie on both sides of the Lower Mississippi; but they chiefly prevail to the W. of it. These savannahs are sometimes rolling, but oftener level and interminable as the ocean, covered with long rank grass of tender green, blended with flowers chiefly of the liliaceous kind, which fill the air with their fragrance. In the southern districts, as Lower Texas, they are interspersed with groups of magnolias, tulip, and cotton trees; and in the N.W. with oak and black walnut. These are rare occurrences, for the prairies may be traversed for many days without meeting with a shrub, except on the banks of the streams, which are beautifully fringed with myrtles, azaleas, kalmias, andromedas, and rhododendrons. On the wide plains the only objects to be seen are countless herds of wild horses, bisons, and deer. The country assumes a more severe aspect in higher latitudes. It is still capable of producing rye and barley in the territories of the Assiniboine Indians, and round Lake Winnipeg there are great forests; a low vegetation with grass follows; and towards the Arctic Ocean the land is barren and covered with numberless lakes and large streams sunk into narrow valleys which flow into that icy sea.

E. of the Mississippi there is a magnificently undulating country, extending 1000 miles from S. to N. between that great river and the Alleghany Mountains, mostly covered with trees. Pine barrens, stretching far into the interior, occupy the whole coast of the Gulf of Mexico eastward, from Pearl River through Alabama and a great part of Florida. These vast monotonous tracts of sand covered with forests of gigantic pine-trees are as peculiarly a distinctive feature of the North American continent as the prairies, and are not confined to this part of the United States; they occur to a great extent in North Carolina, Virginia, and elsewhere. Tenessee and Kentucky, though much cleared, possess large wood-lands; "almost the whole country between the western slopes of the Appalachian Mountains, and the Mississippi, the Wabash, and Lake Michigan, was originally clothed with forest, and much of it still remains." The Ohio flows for hundreds of miles among magnificent trees with an undergrowth of azaleas, rhododendrons, and other beautiful shrubs, matted together by creeping plants. There the American forests appear in all their glory; the gigantic deciduous cypress, and the tall tulip-tree overtopping the forest by half its height, a variety of noble oaks, black walnuts, American plane, hickory, sugar maple, and the liriodendrons, the most splendid of the magnolia tribe, the pride of the forest.

The Illinois waters a country of prairies. Five new States occupy a territory of 280,000 square miles round the great lakes, which contains 180 millions of acres of land of excellent quality. These States lie between the lakes and the Ohio, and they reach from the United States to the Upper Mississippi, a country twice as large as France, and six times the size of England; but almost the whole of this noble plain of North America is unrivalled in every natural advantage.

The quantity of water in the north-eastern part of the central plain greatly preponderates over that of the land; the 5 principal lakes—Huron, Superior, Michigan, Erie, and Ontario—cover an area equal to Great Britain, without reckoning innumerable smaller lakes and rivers.

§ 2. British North America, including the shores of the Polar Ocean and the recently established colony of British Columbia, comprises an area of 4,000,000 of square miles, or nearly a ninth part of the whole terrestrial surface of the globe. Though large tracts on the Arctic Ocean are uninhabitable, there is no perpetual snow over a wide extent of them, and severe winters do not prevent the growth of the cerealia and deciduous trees, for whenever a summer heat of 56° lasts for 100 or 120 days, wheat may be profitably cultivated: the limit seems to be the 65th parallel of latitude, so that even the northern parts are not so desolate as is generally supposed. Canada, by far the most valuable of the British colonies, which occupies the eastern part of this enormous region, has an area seven times the size of England, and 2,500,000 inhabitants. No country in the world surpasses Canada in the produce of wheat; in 1859 it amounted to 25,000,000 of bushels of the very best quality, and in Western Canada the produce had increased 400 per cent. in ten years. Every plant that requires a hot summer and can endure a cold winter thrives there. Whole districts of many square miles are of alluvial soil, from 30 to 80 feet deep, which in some places is so rich as to bear good crops for several successive years without manure, and there are many continuous tracts, especially along the rivers, too rich for wheat.

Although there is much productive soil in Lower Canada yet the largest and finest tracts of land are in Upper, now called Western, Canada, which is a plain of 20,000 square miles, of great fertility, mostly covered with noble forests, which show the strength of the soil. The trees are mostly deciduous, as maple, beech, oak, basswood, elm, hickory, walnut, chestnut, cherry, birch, cedar, and pine. The autumnal tints of these forests, even on cloudy days, are so brilliant that the yellow leaves give the impression of sunshine; each leaf presents a point of sparkling gold. The hues change from day to day, and pink, lilac, vermilion, purple, deep blue, and brown, combine to form a gorgeous mass of colouring that surpasses imagination: even the decay of the aged and fallen trees is concealed by a mantle of geraniums, honeysuckles, foxgloves, and other flowers.

More to the N. deciduous trees become scarcer, and pine forests of great variety prevail. Of the whole 114 species of known pines, 21 are natives of Canada, or the Hudson Bay territory. The balm of Gilead fir, the hemlock and black spruce, are common; the latter is also found in Nova Scotia. The Pinus alba, or white spruce, is one of the most beautiful of the Canadian trees; it grows to the height of 140 feet, with branches feathering down to the ground and leaves of a sea-green hue; but the Weymouth pine is the largest in the Canadian woods, and grows in most of the districts E. of the Rocky Mountains. It frequently grows to the height of 200 feet, but in the Canadian forests it is like a bare spar with a tufted crown, casting a deep gloom below. The fall of large trees from age is a common occurrence, and not without danger, as it often causes the destruction of those adjacent; and an ice-storm is awful.

After a heavy fall of snow, succeeded by rain and a partial thaw, a strong frost coats the trees and all their branches with transparent ice often an inch thick; the noblest trees bend under the load, icicles hang from every bough, which come down in showers with the least breath of wind. The hemlock-spruce especially, with its long drooping branches, is then like a solid mass. If the wind freshens, the smaller trees become like corn beaten down by the gale, while the larger ones swing heavily in the breeze. The forest at last gives way under its load, tree falls after tree with sudden and terrific violence, crushing all before them, till the whole is one wild uproar, heard from afar like successive discharges of artillery. Nothing, however, can be imagined more brilliant and beautiful than the effect of sunshine in a calm day on the frozen boughs, where every particle of the icy crystals sparkles, and nature seems decked in diamonds.[1]

These noble Canadian forests are rapidly falling under the axe: already the largest trees on the rivers have been cut down, the smaller ones only being left, because the great river system of this country affords the means of transporting the timber to the sea by rafts. In 1859 the value of the timber exported amounted to nearly 2,500,000 sterling.

§ 3. That magnificent region, extending from the Canadas to the Pacific Ocean, was for more than a century only known to the Hudson Bay Company, who had many settlements scattered over it for the capture of fur-bearing animals, which are so valuable and numerous that they employed 100,000 Indians in the chase, and it is believed that the value of the fur imported into England since the beginning of the trade amounts to 20,000,000*l*. sterling. Since the discovery of the gold-producing district has led to the establishment of the Colony of British Columbia west of the Rocky Mountains, expeditions have been sent by the British and Canadian governments to examine the nature of the country, and to ascertain the passes over the Rocky Mountains, with a view ultimately to connect the two oceans by a railway 2000 miles long. The country between Lake Superior and the Red River settlement of the Hudson Bay Company consists of chains of rivers and lakes of the most romantic scenery; that on Sturgeon Lake is said to be of the highest order; and the scenery among the islands of the Lake of the Woods is singularly picturesque, consisting of every variety of bare precipitous rock, abrupt timbered hills, gently wooded slopes, and open grassy plains; and so abundant are the flowers on the banks of these secluded lakes that they look like a neglected garden. In fact, the great lakes of the Winnipeg basin, embracing an area of water of 13,000 square miles, are bounded on the west by abrupt and precipitous escarpments, which bear the marks of having been an ancient coast-line when the ocean was relatively 1600 feet above its present level. On their western flanks these ranges descend in steps and gentle slopes to the fertile valleys of the Assiniboine and Swan Rivers, and are densely wooded with valuable timber trees.

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[1] Mr. Taylor.

Captain Palliser, in his exploring expedition, found that the southern branch of the Saskatchewan flows through a sterile country that seems to be part of the great American desert, but he discovered a large navigable river equal to the Missouri in size and volume. It issues from the chain of the Qu'appelle Lakes and joins the Saskatchewan, which, with its tributaries, falls into Lake Winnipeg after having watered the Buffalo prairies. It is estimated that the country drained by the Saskatchewan and the Red River contains 155,000 square miles. Of this land about 80,000 square miles, lying south of the elbow of the Saskatchewan and the Qu'appelle River, would be adapted for grazing. At the base of the Rocky Mountains there is a strip of fertile territory, and on the N. branch of the Saskatchewan there are about 65,000 square miles, one-third of which is fit for immediate cultivation. Though the winter is severe, the number of buffaloes that live on these grounds shows that they are perfectly suited for settlements.

§ 4. It is singular that the lowest passes in the Rocky Mountains should be in the highest part of the chain. Captain Palliser and his party discovered three that might be available for carrying a railway across, all of which are on British ground. The Vermilion Pass is described as a deep gorge between high peaks, and only 4947 feet above the level of the sea; the Kananaski Pass, preferred by Captain Palliser, is through a wide sloping valley, with a comparatively easy descent to the W., which by a tunnel might be reduced to the absolute height of 4600 feet. The third is the Kutanie Pass. The Yellow Head Pass, leading from the Athabasca to the Upper Frazer, has been explored by Dr. Rae. It is N. of the others, in latitude 52° 54′ N., and crosses the mountains by a series of easy gradients, its greatest altitude being 3760 feet. This pass leads into the valley of the Thompson, a tributary of the Frazer, and was the one followed by Lord Milton and Dr. Cheadle in their well-known journey. The valleys of the Thompson and Frazer Rivers are distinguished by a series of raised terraces on a grand scale, which have been traced for 100 miles along the banks of the Thompson and 200 miles along those of the Frazer. These are all perfectly uniform, and correspond on the opposite sides of the valleys. The lower valley of the Frazer is a rugged defile, mountain succeeding mountain between Yale and Lytton, "bluff after bluff of solid perpendicular granite, intermingled with steep slides of rolling rock, washed by a deep impetuous stream, and 1500 to 2000 feet high." It is of extreme importance to establish a communication between British Columbia and the Red River settlement, not only in consequence of the fertility of the latter, but because it lies in the direct line of an interoceanic railway; for Captain Blakeny has shown that the shortest distance, or great circle of the sphere, joining Montreal and New Westminster, the capital and seaport of British Columbia, passes through the Red River settlement; but unless it be speedily united to Canada by a commercial route, it is in danger of becoming a province of the United States.

The Rocky Mountains proper, the great watershed of the continent, may be considered as only the eastern flank of an immense tract of mountainous country. This attains its greatest height where the western flank—the Cascade range—runs like a wall along the coast, only broken by gorges or nicks, through which the Columbia and Frazer Rivers flow into the Pacific. In British Columbia the Rocky Mountains and the Cascade range approach so close to each other that they may be considered to form one vast chain. Farther N. they enclose between them an elevated plateau of rolling country 100 miles in breadth. The Rocky Mountains here form a triple range, averaging from 150 to 160 miles wide, the main crest, which is the most easterly, rising abruptly from an elevated plain to a height of 16,000 feet, the middle and western crests being respectively 12,000, and from 4000 to 8000 feet high. The Cascade range runs at a distance of 20 to 25 miles from the coast far northwards into what was Russian America, but which now forms the Territory of Alaska. Its average width N. of the Frazer River is 110 miles, and it forms a sea of mountains, some of its peaks exceeding 10,000 feet in height, and extending inland till its spurs mingle with those of the Rocky Mountain range. The western slopes of all the mountains are thickly wooded. In the Cascade range there are some fine glaciers, and the coast line penetrates by numerous openings, such as Bute Inlet, far up into the mountains. The scenery is like that of the Norwegian fiords.

The middle and western crests of the Rocky Mountains are gradually depressed N. of Cariboo, and this depression forms a large tract of level and fertile country on each side of the Upper Frazer. The gold region of Cariboo lies in the elbow formed by the Upper waters of the Frazer, and is bounded on the S. by the Quesnelle

River. Every creek in the hills contains gold, and auriferous deposits have been traced throughout the whole length of British Columbia in the valleys of the Frazer and its tributaries. Of the interior of the north-western portion of North America, little is at present known. The seaward slopes of the range, in which Mounts St. Elias and Fairweather rear their mighty crests, are clothed with fine forests, chiefly of pine. Back from these mountains an undulating region extends to the great Yukon River, one of the ranges, the Ululuk Mountains, attaining an altitude of 3000 feet, and forming conspicuous landmarks in a country which is comparatively level. These mountains extend from N. to S. for about 100 miles.

§ 5. The Alleghany or Appalachian chain, which constitutes a second and subordinate system of North American mountains, separates the great central plain from that which lies along the Atlantic Ocean. Its base is a strip of table-land, from 1000 to 3000 feet high, lying between the sources of the rivers Alabama and Yazou, in the southern states of the Union, and New Brunswick, at the mouth of the river St. Lawrence. This high land is traversed throughout 1000 miles, between Alabama and Vermont, by from three to five parallel ridges of low mountains, with an average height of 2500, and in North Carolina reaching 6000 feet, and separated by fertile longitudinal valleys, which occupy more than two-thirds of its breadth of 100 miles. In Virginia and Pennsylvania, the only part of the chain to which the name of the Alleghany Mountains properly belongs, it is 150 miles broad, and the whole is computed to have an area of 200,000 square miles. The parallelism of the ridges, and the uniform level of their summits, are the characteristics of this chain, which is lower and less wild than the Rocky Mountains. The uniformity of outline in the southern and middle parts of the chain is very remarkable, and results from their peculiar structure.[1] These mountains have no central axis, but consist of a series of convex and concave flexures, forming alternate hills and longitudinal valleys, running nearly parallel throughout their length, and cut transversely by the rivers that flow to the Atlantic on the one hand, and to the Mississippi on the other. The watershed nearly follows the windings of the coast from the point of Florida to the north-western extremity of the State of Maine.

The picturesque and peaceful scenery of the Appalachian Mountains is well known; they are generally clothed with a luxuriant vegetation, and their western slope is considered one of the finest countries in the United States. To the S. they maintain a distance of 200 miles from the Atlantic, but approach to the coast in the south-eastern part of the State of New York, from whence their general course is northerly to the banks of the St. Lawrence. But the Blue Mountains, which form the most easterly ridge, are continued in the double range of the Green Mountains to Gaspé Point in the Gulf of St. Lawrence. They fill the Canadas, Maine, New Brunswick, and Nova Scotia with branches as high as the mean elevation of the principal chain, and extend even to the dreary regions of Baffin Bay. The chief Canadian offsets are parallel to the St. Lawrence. The Mealy Mountains, on the E. coast of Labrador, extend from Cape Charles to Sandwich Bay. They rise 1484 feet above the sea-level, and are wooded nearly to their summits. With the Wotchish Mountains, and the elevated land N. of the St. Lawrence, these mountains have recently received the name of the Laurentian range. Little is known of the high lands within the Arctic circle, except that they have a general direction from S.E. to N.W.

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[1] Lyell's Travels in North America.

§ 6. The country between Hudson Bay, the mouth of the Churchill river, and that of the Mackenzie, is also an almost unknown region; on the E. it descends steeply to the coast, but the western part, known as the Barren Ground, is low and destitute of wood, except on the banks of the streams. The whole is covered with low precipitous hills. Not only the deep forest, but vegetation in general, diminishes as the latitude increases, till on the arctic shores the soil becomes incapable of culture, and the majestic forest is superseded by the Arctic birch, which creeps on the ground. Many of the islands along the north-eastern coasts, though little favoured by nature, produce flax and timber; and Newfoundland, as large as England and Wales, maintains a population of 125,000 souls chiefly by its fisheries: it is nearer to Britain than any part of America—the distance from the port of St. John to the harbour of Valentia in Ireland being only 1626 geographical miles.

§ 7. The long and comparatively narrow plain which lies between the Appalachian Mountains and the Atlantic extends from the Gulf of Mexico to the eastern coast of Massachusetts. At its southern extremity it joins the plains of the Mississippi, and gradually becomes narrower in its northern course to New England, where it merely includes the coast-line and islands. It is divided throughout its length by a line of bluffs from 200 to 300 feet high, which commences in Alabama and ends on the coast of Massachusetts. This declivity is the eastern edge of the terrace known as the Atlantic Slope, which rises above the Maritime Plain, and undulates westward to the foot of the Blue Mountains, the most eastern ridge of the Appalachian chain. It is narrow at its extremities in Alabama and New York, but in Virginia and the Carolinas it is 200 miles wide. The surface of the slope is of great uniformity; ridges of hills and long valleys run along it parallel to the mountains, close to which it is 600 feet high. It is rich in soil and cultivation, and affords an immense water-power in the streams and rivers flowing from the mountains across it, which are precipitated over its rocky edge to the plain on the E. More than 23 rivers of considerable size fall in cascades down this ledge between New York and the Mississippi, affording scenes of great beauty.[1]

Both land and water assume a new aspect on the Atlantic Plain. The rivers, after dashing over the rocky barrier, run in tranquil streams to the ocean; and the plain itself is a monotonous level, not more than 100 feet above the surface of the sea. Along the coast it is scooped into valleys and ravines, with innumerable creeks.

The greater part of the magnificent countries east of the Alleghanies is in a high state of cultivation and commercial prosperity, with natural advantages not surpassed in any country. Nature, however, still maintains her sway in some parts, especially where pine-barrens and swamps prevail. The territory of the United States covers an area of 4,060,309 square miles, of which by far the greater part is fertile, and capable of producing everything that is useful to man. The climate is generally healthy, the soil abundant in mineral treasures, and it possesses every advantage from navigable rivers and excellent harbours. Anglo-Saxon civilization is now firmly established on the shores of the Pacific, and the tide of white men is continually and irresistibly pressing onwards to the ultimate extinction of the original proprietors of the soil—a melancholy but not a solitary instance of the rapid extinction of a whole race.

§ 8. The most striking feature in the geology of North America is the enormous development of the Devonian and carboniferous strata to the east, and the still more extensive development of the cretaceous and tertiary formations to the west. The latter stretches from the southern termination of the Appalachian hills in Georgia and Alabama, westward to the table-land of Mexico, north-westward to the eastern foot of the Sierra Nevada, to California and the Cascade chain of Oregon, and northward by the broad plain of the Missouri to an undefined limit in the desert steppes that lie beyond that river and east of the Rocky Mountains. The portions of this enormous area that are tertiary and alluvial are Florida, a large tract at the mouth of the Mississippi, and the whole coast of the Gulf of Mexico; and to the west, the elevated Salt Desert table-lands from the Gulf of California, through Utah, to their farthest extremity. The peninsular chain of California and the Sierra Nevada rise out of these strata; but the Rocky Mountains rise through the cretaceous plain. The Californian chain, the Sierra Nevada, and generally the coast-chains, are metamorphic, the store-house of mineral riches. The gold formation, which seems to be inexhaustible, and which probably extends through Alaska territory, has given rise not only to the settlement of California, but to British Columbia, no doubt destined in the course of time to spread indefinitely over the rich prairies to the east of the Rocky Mountains. These metamorphic coast-chains are mixed with crystalline granite and volcanic rocks of all ages. The latter are greatly developed at the northern termination of the Utah desert, and all along the Pacific coast. The plateau of Sonora consists of Palæozoic with volcanic and trappean rocks, and occasionally crystalline strata. The Rocky Mountains seem to have the same structure, with the addition of extensive tracts of carboniferous limestone.

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[1] The author is indebted to the article on the 'Physical Features of North America,' in the last edition of Keith Johnston's Physical Atlas, by Prof. H. D. Rogers, to the 'Travels' of Sir Charles Lyell, to Palliser's and Waddington's papers in the 'Transactions of the Geographical Society,' to Mr. F. Whymper's 'Alaska,' and to the 'Quarterly Review' for 1st January, 1861, for the greater part of her information on the Physical Geography and Geology of that portion of the New World.

The geology of the eastern part of the continent is of a very different character. Throughout the whole of the United States and the British provinces of the Atlantic coast and the Atlantic plain westward to the Missouri River, and from the end of the Appalachian chain in Alabama and the river Washita in Northern Texas to the territory of Hudson Bay, an area equal to half the breadth of the continent in these latitudes, there is scarcely any strata of later formation than the upper coal-measures. The Devonian and carboniferous strata prevail from the great lakes to about the 36th degree of N. latitude, and from the Atlantic slope to the 97th meridian. They are enormously developed in depth as well as in extent, for the Devonian and carboniferous strata together are a mile and a half thick in the State of New York, where there is no coal; but it is three times as much in Pennsylvania, and the quantity of coal in the United States is sufficient to supply the whole world for ages, and in many places lies quite on the surface. The Appalachian chain consists of the older Palæozoic strata to the west, and to the east there is a wide belt of metamorphic rocks combined with crystalline, and along the Atlantic coast the formations are tertiary and alluvial.

Long lines and patches of the lower Palæozoic rocks are found in Vermont, and among the great lakes; but a very wide and extensive development of crystalline rocks occupies Vermont, Nova Scotia, where gold has recently been found, but more especially Newfoundland, and extends along the northern side of the Gulf of St. Lawrence, occupies Lower and Upper Canada, the country of Minnesota, and from thence stretches to the N.W. in a very broad belt to the E. of Lake Winnipeg. A great deal of granite protrudes through this formation, especially in Newfoundland. All the most northern part of the continent is of Silurian and Cambrian strata.[1]

The geological outline of the United States, the Canadas, and the country round the Polar Ocean, though highly interesting in itself, becomes infinitely more so when viewed in connexion with that of Northern and Middle Europe. A remarkable analogy exists in the structure of the land on each side of the North Atlantic basin. The extensive formation of crystalline rocks interspersed with granite, which has just been mentioned, ranges also through Scandinavia, Finland, and Lapland. In the latter countries, and in the more northern parts of America, Sir Charles Lyell has observed that the fossiliferous rocks belong either to the most ancient or to the newest formations; to the Silurian strata, or to such as contain shells of recent species only, no intermediate formation appearing through immense regions. Palæozoic strata extend for 2000 miles in the middle and high latitudes of North America; they occupy a tract nearly as great between the most westerly headlands of Norway and those that separate the White Sea from the Polar Ocean. Sir Roderick Murchison has traced them through Central and Eastern Europe, and the Ural Mountains, even to Siberia; Messrs. Abich and Tchihatcheff through the Caucasus and Altaï. They have been seen by Messrs. Pentland and D'Orbigny to constitute some of the most elevated pinnacles of the Bolivian Andes; and Colonel Strachey has discovered them at a great elevation in the Himalaya, where they form the summits of the gigantic Jumnotri, and with fossils analogous to those found in the Ural and the Andes. Throughout these vast regions, both in America and in the old continent, the Silurian strata are followed in ascending order by the Devonian and carboniferous formations, which are of such enormous extent in the United States, and which reappear in New Brunswick, Newfoundland, and traces of them may be found in the islands of the Polar Ocean, on the east coast of Greenland, and even in Spitzbergen. A vast carboniferous basin exists in Belgium, above the Silurian strata; two or three of less importance in France; and a great portion of Britain is perfectly similar in structure to North America. The Silurian rocks in many instances are the same, and the coal-fields of New England are precisely similar to those in Wales, 3000 miles off.

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[1] The reader is referred to the excellent maps and letterpress on the geology of North America, by Professor H. D. Rogers, in the new edition of Mr. Keith Johnston's Physical Atlas, and to the Atlas of the United States, Canada, Mexico, &c. &c., by Professor Rogers and A. Keith Johnston, published in 1857.

In all the more northern countries that have been mentioned, so very distant from one another, the general range of the rocks is from N.E. to S.W.; and in Northern Europe, the British Isles, and North America, great lakes are formed along the junction of the strata, the whole analogy affording a proof of the wide diffusion of the same geological conditions in the northern regions at a very remote period. At a later time those erratic blocks which are now scattered over the higher latitudes of both continents were most likely brought from the N. by icebergs, while the land was still covered by the deep, or by glacial movement over the land. Volcanic agency has not been wanting to complete the analogy. The Silurian and overlying strata have been pierced in numerous places by trappean rocks on both continents, and they appear also in the islands of the North Atlantic and Polar Seas.

§ 9. From the similar nature of the coasts, and the identity of the fossil mammalia, on each side of Behring Strait, it is more than probable that the two continents were united, even since the sea was inhabited by the existing species of animals. Some of the gigantic quadrupeds of the old continent are supposed to have crossed either over the land or over the ice to America, to have wandered southward through the longitudinal valleys of the Rocky Mountains, Mexico, and Central America, and to have spread over the large plains of both continents even to their utmost extremity.[1] An extinct species of horse, the mastodon, allied to the elephant, three gigantic edentata, and a hollow-horned ruminating animal roamed over the prairies of North America, certainly since the sea was peopled by its present inhabitants, probably even since the existence of the Indians. The skeletons of these creatures are found in great numbers in the saline marshes on the prairies, called *Licks*, which are still the resort of the existing races.[2]

§ 10. The average height of the continents above the level of the sea is the mean between the height of all the high lands and all the low. Humboldt, by whom the computation was effected, found that the table-lands with their slopes, on account of their vast extent and mass, have a much greater influence upon the result than mountain-chains. For example, if the range of the Pyrenees were pulverised, and strewed equally over the whole of Europe, it would only raise the soil 6 feet; the Alps, which occupy an area four times as great as that on which the Pyrenees stand, would only raise it 22 feet; whereas the compact plateau of the Spanish peninsula, which has only 1920 feet of mean height, would elevate the soil of Europe 76 feet; so that the table-land of the Spanish peninsula would produce an effect nearly four times as great as the whole system of the Alps.[1]

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[1] Sir John Richardson on the Fauna of the High Latitudes of North America.

[2] Lyell's Travels in North America.

A great extent of low land necessarily compensates for the high—at least it diminishes its effect. The mean elevation of France, including the Pyrenees, Jura, Vosges, and all the other French mountains, is 870 feet, while the mean height of the whole European continent, of 1,720,000 square miles, is only 670 feet, because the vast European plain, which is nine times as large as France, has a mean altitude of but 380, although it has a few intumescences, which, however, are not much above 1000 feet high, so that it is 200 feet lower than the mean height of France.[2]

The great table-land of Eastern Asia, with its colossal mountain-chains, has a much less effect on the mean height of Asia than might have been expected, on account of the depression round the Caspian Sea; and still more from the very low level and the enormous extent of Siberia, which is as large as all Europe. The intumescences in these vast plains are insignificant in comparison with their vast area, for Tobolsk is only 115 feet above the level of the sea; and even on the Upper Angora, at a point nearer the Indian than the Arctic Sea, the elevation is only 830 feet, and the third part of Asia has a mean height of only 255 feet. The effect of the Great Gobi, that part of the table-land lying between Lake Baikal and the wall of China, is diminished by a vast hollow 2560 feet deep, the dry basin of an ancient sea of considerable extent near Ergé, so that this great desert has a mean height of but 4220 feet, and consequently it only raises the general level of the Asiatic continent 128 feet, though it is twice as large as Germany. The table-land of Tibet, whose mean elevation, according to Humboldt, is 11,600 feet, together with the chains of the Himalaya and Kuen-lun, which enclose it, only produces an effect of 358 feet. On the whole, the mean level of Asia above the sea is 1150 feet.[1]

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[1] A chain of mountains is assumed to be a three-sided horizontal prism, whose height is the mean elevation of the chain, and the base the mean length and breadth of the same, or the area on which the chain stands, and thus its mass may be computed approximately. It is evident that a table-land must have a greater effect on the mean height of a continent than a chain of mountains, for, supposing both to be of the same base and altitude, one would be exactly double the other; and even if the mountains be the higher of the two, their upper parts contain much less solid matter than their lower on account of the intervals and deep valleys between the peaks.

[2] According to M. Carpentier, the area of the base of the Pyrenees is 1720 square English miles. As the mean elevation of the passes gives the mean height of the mountains, Baron Humboldt estimated from the height of 23 passes over the Pyrenees that the mean crest of that chain is 7990 feet high, which is 300 feet higher than the mean height of the Alps, though the peaks in the Alps have a greater elevation than those of the Pyrenees in the ratio of 1$\frac{1}{10}$ to 1.

Notwithstanding the height and length of the Andes, their mass has little effect on the continent of South America on account of the extent of the eastern plains, which are one-third larger than Europe. For if these mountains were reduced to powder and strewn equally over them, it would not raise them above 518 feet; but when the minor mountain systems and the table-land of Brazil are added to the Andes, the mean height of the whole of South America is 1130 feet. North America, whose mountain-chains are far inferior to those in the southern part of the continent, has its mean elevation increased by the table-land of Mexico, so that it has 750 feet of mean height.

The mean elevation of the whole of the New World is 930 feet above the level of the sea, and that of the continental masses of Europe and Asia 1010 feet. Thus it appears that the internal action in ancient times has been most powerful under Asia, somewhat less under South America, considerably less under North America, and least of all under Europe.[2]

So little is known of the bed of the greater part of the ocean that no inference can be drawn with regard to its heights and hollows, and what relation its mean depth bears to the mean height of the land. From its small influence on the gravitating force, La Place assumed it to be about four miles.[3] As the mean height of the con-

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[1] The Russian Academicians MM. Fuss and Bunge found by barometrical measurement the mean height of that part of the Eastern Asiatic table-land lying between Lake Baikal and the Great Wall of China to be only about 6960 feet. The smallness of this mean is owing to hollows in the table-land, especially in the desert of the Great Gobi.

[2] By the measures and calculations of Baron Humboldt and Mr. Pentland, the elevation of the highest peaks, and the mean heights of the Himalaya, of the Equatorial and Bolivian Andes, and the Alps, are as follow:—

	Peaks.	Mean Height.
Himalaya	29,002	15,670
Andes between 5° N. and 2° S. lat. ..	21,424	11,380
Eastern Cordillera } Between 18° and 15° S. lat.	21,300	15,250
Western Cordillera	22,350	14,900
Alps	15,739	7,353

The Peak of Dhawalaghiri is 26,862 feet high, and Mount Everest, or the Peak of Déodhunga, between Nepaul and Sikim, 29,002.

[3] The greatest depth hitherto attained by soundings is nearly four statute miles, or 6,500 yards, by our naval surveyors, in the South Atlantic near the equator, between 24° and 25° W. longitude.

tinents is about 1000 feet, and their extent only about a fourth of that of the sea, they might be easily submerged, were it not that, in consequence of the sea being only one-fifth of the mean density of the earth, and the earth itself increasing in density towards its centre, La Place has proved that the stability of the equilibrium of the ocean can never be subverted by any physical cause: a general inundation from the mere instability of the ocean is therefore impossible.

CHAPTER XIV.

ISLANDS OF THE PACIFIC AND INDIAN OCEANS.

§ 1. Continent of Australia; general description; New South Wales; Sydney; southern mountain system; north-western explorations by M'Dougall Stuart; Mr. Gregory's expedition in North Australia; productions and climate of the continent. § 2. Island of Tasmania or Van Diemen's Land. § 3. Geology of Australia. § 4. Classification of islands; continental islands; pelagic islands. § 5. New Zealand. § 6. New Guinea and the Aru islands. § 7. Borneo and the Malay archipelago; labours of Sir James Brooke.

§ 1. THE continent of Australia being nearly destitute of large navigable rivers, it was concluded that no very high land existed in its interior, even before it had been explored. The eastern half of the interior is now tolerably well known, and it has been found to constitute a vast shallow basin, the drainage of all the rivers flowing from the western slopes of the eastern coast-range of mountains, N. of the tributaries of the Murray, finding its way into a chain of salt-lakes by Cooper's Creek or the Barcoo River. A similar interior basin is supposed to exist in the western half. Thus the continent would appear to be constituted by a ring of moderately high land round its coasts, enclosing a great shallow depression in its interior. It is 2400 miles from E .to W., and 1700 from N. to S., and is divided into two unequal parts by the Tropic of Capricorn; consequently it has both a temperate and a tropical climate. New Guinea, separated from Australia by Torres Strait, and traversed by the same chain of mountains with Australia and Tasmania, is so similar in its productions that it may be regarded as a detached member of the adjacent continent.

The coasts of Australia are indented by very large bays, and by harbours that might give shelter to all the navies in Europe. The most distinguishing feature of the eastern side, which is chiefly occupied by the British colonies of Queensland and New South Wales, is the height and continuity of its coast-chain of mountains which never retires far from the coast, and, with the exception of some short deviations in its southern part, maintains nearly a meridional direction through 35 degrees of latitude. It is continued at one extremity from Torres Strait, N. of the Gulf of Carpentaria, far into the interior of New Guinea; and at the other it traverses the whole of Tasmania. In the northern parts of Australia, it forms in some places merely the lofty escarpment of a table-land; but about the 29th degree of S. latitude it assumes the form of a regular mountain-chain, and, running in a tortuous line from N.E. to S.W., terminates its visible course at Wilson Promontory, the southern extremity of the continent. It is continued, however, by a chain of mountainous islands across Bass's Strait to Cape Portland, in Tasmania; from thence the range proceeds in a zigzag line of high and picturesque elevations to South Cape, where it ends, having a total length of 1500 miles.

The distance of the chain from the sea in New South Wales is from 50 to 100 miles, but at the 32nd parallel it recedes to 150, yet soon returns, and forms the wild group of the Corecudgy Peaks, from whence, under the names of the Blue Mountains and Australian Alps, its highest part, it proceeds in a general southerly direction to the land's end.

The height of these mountains is only from 2400 to 4700 feet above the level of the sea, and even Mount Kosciusko, the loftiest of the Australian Alps, is not more than 7285 feet high; yet its position is so favourable that the view from its snowy and craggy top sweeps over an area of 7000 square miles. The rugged and savage character of these mountains far exceeds what might be expected from their height: in some places, it is true, their tops are rounded and covered with forests; but by far the greater part of the chain, though wooded along the flanks, is crowned by naked needles, serrated peaks, and flat crests of granite or porphyry, mingled with patches of snow. The spurs give a terrific character to these mountains, and in many places render them altogether inaccessible, both in New South Wales and Tasmania. These shoot right and left from the axis of the main range, equal to it in height, and separated from it, and from each other, by dark and almost subterraneous gullies, like rents in the bosom of the earth, ironbound by impracticable precipices, with streams flowing through them in black silent eddies or foaming torrents. The intricate character of these ravines, the danger of descending into them, and the difficulty of getting out again, for a long time rendered this mountain chain, in New South Wales at least, almost an impassable barrier between the country on the coast and that in the interior.[1]

In New South Wales the country slopes westward from these mountains towards a flat, low, unbroken plain. On the E., dark, verdant, round-topped hills and ridges are promiscuously grouped together, leading to a richly wooded undulating country which gradually descends to the coast and forms the valuable lands of the British colony. Discovered by Cook in the year 1770, it was not colonized till 1788, and since that time the Australian colonies that have been established have risen to the most unprecedented prosperity; they contain a million and a half of inhabitants; the exports in 1866 amounted to nearly 26 millions of pounds sterling; and they took in that year more than 11 millions worth of British produce: they administer their own laws, and the principal towns have their house of representatives. On the Australian continent there are five colonies. On the E. there are Queensland, which includes the whole of the north-eastern portion; New South Wales, the oldest settlement, lying S. of Queensland and N. of the Murray River; and Victoria, which occupies the south-eastern corner, and lies S. of the Murray, and E. of 141° E. long. South Australia had for its eastern and western boundaries 132° and 141° E. long., and for its northern limit, lat. 26° S. In 1863, the boundaries of the colony were extended so as to embrace all the territory lying northward of 26° S. and between the 129th and 138th degrees of E. long. Western Australia includes all that portion of New Holland situated westward of 130° E. long.; but only a small area in the southern part of this district, around Swan River, is occupied; an attempt lately made to colonize from Swan River the tropical portion of the colony near Brecknock Harbour has for the present failed.

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[1] Memoirs of Count Strzelecki.

Sydney, the capital of New South Wales, is a large handsome city, which, together with its environs, contains 150,000 inhabitants. It has various public buildings in good architectural taste, and contains the luxuries and comforts of European society. It is seven miles from the land-locked harbour of Port Jackson, and the approach to it is pretty, from the number of ornamental villas on the banks of the water and the mixture of the native vegetation with that of southern Europe, which has been largely imported. Melbourne, the capital of Victoria, is situated on the Yarra Yarra, a river which flows into Hobson's Bay, the most northern arm of Port Phillip, and which is only navigable for small vessels. The town was only founded in 1837; but it is estimated to contain at present a population of 250,000, so rapidly have the gold-fields attracted emigrants. It contains many handsome public buildings, and its botanic garden is of considerable importance. It has five or six museums, a public library of 40,000 volumes, a dozen hospitals, and a university. The town is situated two miles by land from Hobson's Bay, but seven or eight miles by the river. Its port is Williamstown on Hobson's Bay, and on the shores of Port Phillip are Brighton, St. Kilda, and other places, which are almost suburbs to Melbourne. There are many other flourishing and populous towns in New South Wales, Victoria, and Queensland; the improved navigation of the Murray has tended greatly to the prosperity of this part of the continent. From Spencer Gulf, which has three excellent harbours, one of which could contain the whole British navy, that river has been navigated for 2650 miles, and it is estimated that 1150 more may be added by the improved navigation of three of its tributaries. In consequence of this increased water-carriage many new towns have been built, some of which are of considerable size. There is much grass-land in this district; and if artesian wells can be dug in the vast salt-bush countries still unoccupied, a prodigious increase of cattle and sheep might be maintained. This internal navigation extends to the different auriferous districts; and as 1300 miles of it lies within the territory of New South Wales, it unites the traffic and mutual interests of three of our greatest Australian colonies.

In the southern half of the continent the mountain and hilly ranges are called the Pyrenees and Grampians in Victoria, the Flinders Range in South Australia, and the Darling Range in Western Australia. Strong westerly, generally south-westerly, or sometimes north-westerly winds prevail over the southern part of the continent during the greater part of the year, and, owing to precipitation of rain from these up to the 30th parallel of S. latitude, there are fertile tracts on the seaward sides of the mountains; but these winds in passing over the mountain-tops are drained of their moisture, so that on their inland sides barren wastes prevail. There is a comparatively fertile country on the strip of land W. of the Darling Range, which is from 3000 to 4000 feet high: it is a grassy woody country, and rain frequently falls.

Recent explorations of the interior of Australia have produced results which were somewhat unexpected. Sturt's journey in 1843 had led him to a stony desert in lat. 24° S., long. 138° E., and that of Gregory, from the N.W., to a sandy desert in lat. 21° S., long. 128° E. Mr. Eyre's adventurous journey along the shores of the great Australian Bight in the S. had shown them to be destitute of fresh water. It was therefore supposed that a great sandy desert lay in the interior. But explorations of the N. coast showed that many rivers, such as the Albert, Flinders, Murchison, Grey, Fitzroy, Roper, and Victoria, rose on the edge of a sandstone table-land, and that this ridge also gave rise to streams which flowed towards the interior. Early efforts to cross to the Gulf of Carpentaria had resulted in the discovery of Cooper's Creek, now called the Victoria or Barcoo River, a stream which has been traced for more than 600 miles, and which has a south-westerly course towards the interior of the continent; and a supposition arose that the rivers draining the inner edge of the table-land flowed towards a great interior lake—a theory which was even older than that of the desert.

The first complete traverse of the continent was made by the explorers Burke and Wills, who crossed nearly in the meridian of 142° E., finding creeks, grassy plains, and but a small extent of stony desert. Unfortunately, on their return towards the S., their provisions ran short, they missed the party sent to their relief, and died of starvation on Cooper's Creek, their journals, however, being preserved by King, one of the party, who was found when in the last stage of exhaustion. M'Dougall Stuart made several journeys northward from Adelaide, in the course of one of which he discovered Central Mount Stuart, and found hills, grassy flats fit for sheep-farms, and water either in creeks or easily to be obtained by digging. The eastern half of what was considered the central desert has been crossed three times by Stuart, also by Walker and Landsborough, and McKinlay passed from South Australia by way of Carpentaria to Queensland, driving a flock of sheep before him. M'Intyre and others have also traversed the continent; in fact, it has become quite common to cross from the Parroo to Carpentaria.

It is found that no great horse-shoe lake, such as Lake Torrens was imagined to be, exists. In its place there is a group of lakes, Eyre, Gregory, Torrens, Frome, &c. The basin of Lake Eyre is only 70 feet above the sea-level. The general configuration of Australia, in fact, is that of a ring of high land, enclosing a vast interior area of depression in which all the internal drainage is enclosed without exit to the sea.

The watershed of the northern part of the continent is on the edge of a sandstone plateau which runs from E. to W., and is found between the 19th and 22nd parallels of S. latitude. In the W. this edge has an altitude of 800, and in the E. of 1900 to 2000 feet above the sea. On the coast side the table-land is abrupt, and cleft with many beautiful valleys. Basalt and other igneous rocks are sometimes found protruding through the sandstone, and where this is the case, the soil is of great fertility. To the N. of the plateau are long grassy flats, sometimes wooded; and, succeeding these, there are frequently mangrove swamps, where the rivers reach the sea. The table-land itself is rather bare, and the great south-western slope, between 135° and 145° E., abounds in dividing ridges of sandstone, which, when broken up, present a desert-like appearance, though sometimes, and most frequently, good grass, fine soil, and gum forest are found. The rivers which run northward from the plateau flow in well-defined beds; but those that flow southward have shallow beds, and are subject to both excessive inundation and evaporation at different times of the year. The watercourses of the interior drain to the Barcoo. Some break up into innumerable creeks and rills without definite direction. Bourke Creek, in lat. 25° S., long. 140° E., often causes immense inundations. The stony deserts where they occur seem to be the result of inundations, whose waters, when dried by rapid evaporation, leave the ground bare. Of the western part of the centre of Australia, almost nothing is known. It will be a field for future explorers.

While the sun is N. of the equator, in the winter of the southern hemisphere, the winds are from the S.E. all over the northern part of the continent with little and only occasional rain. These winds are the regular trades. But in October and November, the wind changes to the north-westerly monsoon, and brings with it rain. The monsoon shifts back to the S.E. in April. In January, February, and March, the heavy falls of rain and the soaked state of the soil give rise to the inundations in the neighbourhood of Bourke's Creek.

One of the results of Mr. Gregory's very interesting expedition in North Australia is the discovery of a table-land of sandstone of no great elevation that runs along the northern coast from Cambridge Gulf to the Gulf of Carpentaria, where it sinks down, its highest part being S. of Port Essington. This is part of the ring of higher land which forms the circumference of the Australian interior. It is traversed by the rivers Adelaide, Roper, and Alligator; and the river Victoria extends to a considerable distance into the interior, and runs through a fertile region of more than 3,000,000 of acres of the finest pasture land, which may in future become a flourishing British colony. The land at the Gulf of Carpentaria is fit for the cultivation of cotton and other tropical productions. Burketown has been founded at the bottom of the gulf; and an establishment on Sweer's Island has been commenced. The energy of the Australians does honour to the Anglo-Saxon race in the perilous and disinterested journeys of discovery they have made under the greatest privation and difficulty.

However unpropitious the centre of the continent may be, there is abundance of fine country inland from the coast. All tropical productions might be raised, and in so large a continent there must be extensive tracts of arable land, though its peculiar character is pastoral. N. of Sydney, and in Queensland up to the 16th degree of S. latitude, both cotton and silk are produced, as well as wines of excellent quality; and the higher land parallel to the coast is occupied by sheep and cattle farmers nearly to the Gulf of Carpentaria. There are large forests on the mountains and elsewhere, yet that moisture is wanting which clothes other countries in the same latitudes with rank vegetation. In the colonies the clearing of a great extent of land has modified in some degree the mean annual temperature, so that the climate has become hotter and drier, and not thereby improved.

§ 2. Tasmania, of triangular form, has an area of 24,000 square miles, and is very mountainous. No country has a greater number of deep, commodious harbours, which occur in the N., S.E., and S. coasts; and, as most of the rivers, though not navigable to any distance, end in arms of the sea, they afford secure anchorage for ships of any size. The mountain-chain that traverses the colony of New South Wales and Furneaux Island in Bass's Strait rises again from Cape Portland, and, winding through Tasmania in the form of the letter Z, separates it into two nearly equal parts, with a mean height of 3750 feet, and at an average distance of 40 miles from the sea. It encloses the basins of the Derwent and Huon Rivers, and, after sending a branch between them to Hobart Town, ends at South Cape. Its highest point is Mount Humboldt, in the S.W., 5520 ft. The mountains of the W. are almost entirely unexplored; but snow-capped peaks are seen among them. The offsets which shoot in all directions are as savage and full of impassable chasms as the range itself. Frightful precipices occur. One in Ben Lomond has a perpendicular depth of 3000 feet. There are cultivable plains and valleys along the numerous rivers and large lakes by which the country is well watered; so that Tasmania is more agricultural and fertile than the adjacent continent, but its climate is wet and cold. The uncleared soil of both countries, however, is far inferior to that in the greater part of North or South America.[1]

§ 3. Granite constitutes the entire base of the western portion of New South Wales, and extends far into the interior of the continent, bearing a striking resemblance in character to a similar portion of the Altaï chain described by Baron Humboldt. The central axis of the mountain-range, in New South Wales and in Tasmania, is of granite, syenite, and quartz rock; but in early times there had been great invasions of volcanic substances, as many parts of the main chain, and most of its offsets, are of the older Plutonic rocks. The fossiliferous strata of the two colonies are mostly of the Palæozoic period, but their fossil fauna is poor as regards the number of species. Some are identical with, and others are representatives of, those of other countries, even of England. There is an unbroken range of cliff from 200 to 500 feet high of horizontal tertiary strata, which stretches from Southern Australia to Western Australia without a single valley or watercourse. As the flat country, wherever it has been traversed, is of the same structure, it is presumed that the low country throughout the interior of the Australian continent consists of horizontal tertiary beds, which are all more or less porous; the limestone strata are tolerably thin and interstratified with beds of sand. It appears, from the flora of the coal formation of these countries, that the vegetation was as distinct from that of the northern hemisphere at the carboniferous period as it is at the present day.

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[1] Count Strzelecki.

The richness of the gold alluvium at the foot of the Australian Alps has changed the character of New South Wales from that of a thinly peopled pastoral country to one of the most rising and flourishing colonies that has sprung from the Anglo-Saxon race. As early as 1844 Sir R. Murchison predicted that Australia, from the similarity in direction of its mountain-chains, and of its rocks, with those of the Ural, then recently explored by him, would become one day a gold-producing country, but no one could have foreseen its excessive richness. Both the chains in question, in those parts where gold is found, consist of metamorphic strata, of schist, sandstones, and limestones of the Palæozoic age, traversed by igneous rocks. But they differ in this respect, that, while in the Ural the gold only exists on the eastern or Siberian side, in the Australian Alps it is on the western. Specimens were occasionally brought to Sydney by shepherds and labouring men, and, as soon as it was known that gold was to be found in large quantities, multitudes flocked to Australia from every quarter, and to such an extent had the search been carried that, in the year 1852, the province of Victoria yielded gold to the value of 8,375,128*l*. In addition to this, in the same year, New South Wales returned the amount of 2,212,534*l*., making in all in one year from Australia 10,587,662*l*. sterling. In 1856, gold to the value of 12,633,138*l*. was found. Since then, however, the supply has greatly declined, and in 1866 the total yield from Australia was only 6,857,223*l*. The greater part was from the alluvial deposits on the earth's surface, which had been spread at different elevations in former periods of powerful abrasion by water, which wore away the auriferous rocks and scattered their treasures on the surface below. Very large masses have frequently been found, but generally the gold is met with in large and small grains.[1]

The principal gold-fields in Victoria are the Ballarat district, W. of Melbourne; the Beechworth district, in the valley of the Ovens; the Sandhurst, or Bendigo district, N. of Mount Alexander; the Maryborough district, between the Avoca and the Loddon; the Castlemaine district, around Mount Alexander in the valley of the Campaspe; and the Ararat district, round Mount Ararat in the Pyrenees, to the N.W. of Ballarat.

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[1] The quantity of gold brought from California during the year 1857 amounted to 14,000,000*l*. sterling.

Except at Ballarat, the gold now obtained is chiefly got by crushing the rock in which it is contained. The Rev. W. B. Clarke, an excellent geologist, pointed out the gold-fields of the Snowy River, which descends to the S. from the high Alps at Mount Kosciusko, and he now has shown that a gold-bearing country exists in Queensland, which is probably not less than 900 miles in length from S.E. to N.W. The Cape River Gold-field, about 200 miles inland from the seaport town of Bowen, is worked by a considerable number of miners.

§ 4. Though the innumerable islands that are scattered through the ocean and seas differ much in size, form, and character, they have been grouped by M. von Buch into the two distinct classes of Continental and Pelagic islands, most of the latter being either of volcanic or coral formation. Continental islands are long in proportion to their breadth, and follow each other in succession along the margin of the continents, as if they had been formed during the elevation of the mainland, or had subsequently been separated from it by the action of the sea, and still mark its ancient boundary. These islands, which follow one another in their elongated dimensions, generally run parallel to the maritime chains of mountains, and are mostly of the same structure, so that they suggest the idea of a submarine portion of the maritime range that has not yet completely emerged from the deep—or, if having sunk down, has not yet disappeared below the waves.

America offers numerous examples of this kind of island. On the north-western coast there is a long chain of them, beginning with the New Norfolk group and ending with Vancouver Island, all similar and parallel to the maritime chain. Another range of continental islands occurs at the southern extremity of America, extending from Chiloe to Cape Horn, evidently an exterior range of the Patagonian Andes, and the southern prolongation of the granitic or coast-chain of Chile; in the Gulf of Mexico, the ancient margin of the mainland is marked by the curved group of Porto Rico, San Domingo, Jamaica, and Cuba, which nearly joins the peninsula of Yucatan. The various islands along the American coast of the Polar Ocean are probably the shattered fragments of the continent.

The old continent also affords innumerable examples; along the whole coast of Norway, from North Cape southwards, there is a continuous chain of rocky islands similar and parallel to the great range of the Scandinavian Alps; Great Britain itself, with the Hebrides, Orkney, and Shetland islands, are remarkable instances of continental islands. It would be superfluous to mention the various instances which occur in the Mediterranean, where many of the islands are merely the prolongations of the mountain-chains of the mainland rising above the sea, as Corsica and Sardinia, which are an offset from the Maritime Alps.

The great central chain of Madagascar and its elongated form, parallel to the mountains and south-eastern margin of the great African table-land, show that the island once formed part of the continent. Asia, also, abounds in similar instances, as Sumatra, Java, and the Moluccas, and another vast chain extends along the western coast from Formosa to Kamtchatka.

Pelagic islands have risen from the bed of the ocean, independently of the continents, and generally far from land. They are mostly volcanic, altogether or in part; often very lofty; sometimes single, and frequently grouped together, and each group has, or formerly has had, a centre of volcanic action in one or more of the islands, round which the others have been formed. Many have craters of elevation, that is to say, they have been raised up in great hollow domes by the internal elastic vapours, and have either remained so, have become rent at the surface into gigantic fissures, or have collapsed into hollow cups, when the pressure from below was removed:[1] a considerable number have active vents.

The small islands and groups scattered at enormous distances from one another within the Antarctic Circle are all of volcanic formation, though none are active. In the Atlantic, Tristan da Cunha, St. Helena, Ascension, and Madeira are volcanic, though not now actively so; whereas the Cape de Verds, Canaries, and Azores have each burning volcanic vents:[2] the peak of Teyde, in Teneriffe, is one of the most magnificent volcanic cones in the world.

The labyrinth of islands scattered over the Pacific Ocean for more than 30 degrees on each side of the equator, and from the 130th eastern meridian to Sumatra, which all but unites this enormous archipelago to the continent of Asia, has the group of New Zealand and the continent of Australia, with its appendage, Tasmania, on the S., and altogether forms a region which, from the unstable nature of the surface of the earth, is partly the wreck of a continent that has been engulphed by the ocean, and partly the summits of a new one rising above the waves. This extensive portion of the globe is in many parts *terra incognita* with regard to the interior of the islands, but is becoming every day less so.

§ 5. New Zealand, divided into three islands, North, South, (Middle), and Stewart's Island, by rocky and dangerous channels, is superior to Australia in richness of soil, fertility, and beauty; it abounds in a variety of vegetable and mineral productions. High mountains, of volcanic origin, run through the islands, which, in the most northerly, rise to nearly 10,000 feet above the stormy ocean around, buried two-thirds of their height in permanent snow and glaciers, exhibiting on the grandest scale all the Alpine characters, with the addition of active volcanoes on the eastern and western coasts: that of Tangariro pours forth deluges of boiling water, which deposit vast quantities of silicious sinter like the Geysers in Iceland; and such is the vitality of the vegetation that plants grow richly on the banks and even in water too hot to be endured. Broad and lofty mountains occupy the centre of North Island, and send off spurs to the sea-coast. These spurs are densely wooded. The island consists of a main body, which sends off four great peninsulas, the most northerly of which is nearly cut through by Hauraki Gulf on the E. and Manakau Harbour on the W., on the narrow isthmus between which stands Auckland. S. of Tangariro is Ruapahu, the highest summit in the central range (9000 feet). Mount Egmont, near the S.W. corner of the island, is an extinct volcano, whose summit is covered with snow, and whose flanks are clothed with magnificent forests; its height is 8840 feet. Mount Edgecumbe towers over the Bay of Plenty to a height of 9630 feet. The scenery is of extraordinary grandeur and beauty. Many of the streams rise in lakes. The largest lake is Taupo, about 36 miles long by 25 miles broad. It gives rise to the Waikato River.

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[1] M. von Buch.

[2] These two last groups of islands have been admirably illustrated, since the publication of the first edition of this work, by the beautiful charts of Captains Arlett and Vidal, published by the Admiralty under the late Sir Francis Beaufort's direction. They are equally interesting to the geologist and to the navigator.

South, formerly Middle Island, has the form of a parallelogram, broken by the great projection of Banks' Peninsula on the E. coast. It is traversed by a chain of mountains which runs much nearer to the western than the eastern coast, and which in the province of Canterbury reaches its greatest altitude, in a range named the Southern Alps. Here Mount Cook towers "like a large white tent" to a height of 13,200 feet, presenting a spectacle of great magnificence. Mount Tyndall is over 11,000 feet in height; and the average height of this portion of the chain is more than 10,000 feet. Farther to the S., in Otago and Southland, the mountains rise from 4000 to 9000 feet; and, as the snow-line is at the height of 8000 feet, many of these summits are covered with perpetual snow. The glaciers of .the Southern Alps are very grand, they descend in some instances to about 3000 feet above the sea-level. The Tasman Glacier, the largest, has a length of 12 miles; and at its terminal face (2772 feet above the sea-level) its breadth is 1¾ mile. There are many others of great extent; on the slopes of Mount Forbes large glaciers are situated, which, after the melting of the snow or heavy rains, send down two waterfalls 800 feet high. A series of lakes of glacial origin, and many of them of considerable extent, are found on the eastern slopes of the mountains. The largest of these are Lakes Te Anau and Wakatipu, and the most picturesque, Lake Pukaki. The steep slopes are on the western side; on the eastern, large lateral chains almost as high as the main chain, run N. and S. The valleys are covered with dense forests, and the mountain sides with Alpine and sub-Alpine vegetation. Five passes between the eastern and western coasts have been explored, the lowest being the Haast Pass, 1716 feet in elevation. The routes by Arthur Pass (3038 feet) and the Harper Pass (3008 feet) are however most likely to be preferred, as they are shorter than that by the Haast Pass, are not often obstructed by snow, and not subject to avalanches. On the S.W. coast are a number of fiord-like openings. The aspect of the coast from Dusky Bay to Milford Sound is gloomy and forbidding in the extreme, with steep black mountains, rising abruptly from the water's edge.

New Zealand has some fine harbours, which are chiefly found on the eastern coasts of the islands. It has much good land, and the grains, fruits, and timber-trees of England flourish. Ferns and coniferæ abound. The kauri or yellow pine is found in the N.W. of North Island; the red, black, and white pines, the ironwood, the red, black, and white beeches, are among the native timber trees. Gold is worked in Auckland, Nelson, and Otago Provinces, and also on the W. coast of Canterbury Province, at Hokitika, the yield in Otago almost rivalling that of the Australian gold-fields. Iron is widely distributed; the beach of Taranaki (in North Island) is for miles formed of fine iron sand. The climate is varied, but has a greater annual rainfall than that of Great Britain, to which it is sometimes compared. The direction of the great mountain-chain being athwart that of the almost constant winds from the Pacific, their influence on the climate is great. They break the force of the wind, and condense the moisture, which takes the form of snow on the high summits. Earthquakes are common on both sides of Cook's Straits.

New Zealand is now divided into nine provinces, Auckland, Taranaki, Wellington, and Hawke's Bay in the North Island, and Nelson, Marlborough, Canterbury, Otago, and Southland in South Island. The much smaller Stewart's Island is uninhabited, and many think uninhabitable. It has, however, several safe harbours.

A very different scene from the stormy seas of New Zealand presents itself to the N. of Australia. There, vivified by the glowing sun of the equator, the islands of the Indian Archipelago are of matchless beauty, crowned by lofty mountains, loaded with aromatic verdure, that shelve to the shore or dip into a transparent glassy sea. Their coasts are cut by deep inlets, and watered by the purest streams, which descend in cascades, rushing through wild crevices. The whole are so densely covered with palms and other forms of tropical vegetation that they seem to realize a terrestrial paradise.

§ 6. Papua, or New Guinea, the largest island in the Pacific after Australia, is nearly 1400 miles long and 400 broad in its widest part, with mountains rising above mountains, till in the W., capped with snow, they attain the height of 16,000 feet. From its position so near the equator it is probable that New Guinea has the same vegetation with the Spice Islands to the W. It appears to be everywhere covered with luxuriant forests, and, from the little that is known of it, must be one of the finest countries in existence. Storms are frequent; rain falls in torrents; earthquakes are rare and never violent.[1] The Aru Islands lie about 200 miles from the south-western coast of New Guinea, a shallow channel lying between them. The group consists of one very large island in the centre, round which are scattered a number of small ones. The large island, Yana-bŭsar (the main-land) is of an irregular oblong form, and is traversed from E. to W. by three narrow channels, which divide it into four portions. The channels are like river-beds, and Mr. Wallace considers that they probably were so when the islands formed part of New Guinea. The Aru Islands, though low, have an undulating surface, cut here and there into deep ravines. The rock everywhere is coralline limestone, from the cliffs of which the edible birds' nests of Aru are taken.

The forests are inhabited by birds of paradise and a great variety of cockatoos and lories. The mother-of-pearl oyster, an inferior kind of pearl oyster, the tripang, a species of holothuria, and the shell tortoise are found on an extensive bank on the eastern side of the group, and the fishing for these is the chief employment of the natives, who of all the Oriental negroes are the most docile and industrious. Some are Christians, some Mohammedans, and others are heathens. From the similarity or identity of plants and animals, man included, Mr. Wallace, to whom is owing the preceding information, thinks that the Aru group once formed part of New Guinea.

§ 7. Borneo, next in size to New Guinea, is a noble island, so large that the whole of the British Islands might be set down in it, and would be even then surrounded by a sea of forest. It is divided into two nearly equal parts by the equator, and traversed through its whole length by chains of mountains, which end in three branches at the Java Sea. Beautiful rivers flow from them to the plains, and several of these are said to spring from a spacious lake on the table-land in the interior, among the peaks of Keni-Balu, whose absolute elevation is estimated at 13,000 or 14,000 feet. No European has been at this lake, but the Malay lake is known to be eight leagues long by four broad, and situated about 45 leagues from the western coast. Borneo is covered with magnificent primeval forest. Among the vegetable productions of this island are palms, bamboos, which are of infinite economical service to the Dyaks; ferns and tree-ferns, pitcher-plants, numerous orchids, few of which have conspicuous flowers; the mangosteen, and other tropical fruits, among which is the durian, to eat of which " is a new sensation, worth a voyage to the East to experience." Rice is largely grown. The vast forests are the home of the Orang-Utan, an animal which is confined to Sumatra and Borneo. Many of the mountains are exceedingly picturesque, and behind Saráwak is "a most beautiful country, where limestone mountains with their fantastic forms and white precipices shoot up on every side draped and festooned with a luxuriant vegetation." Borneo has no signs of recent volcanic action, and earthquakes are entirely unknown. It has a coast-line of about 2000 miles, with few bays and no great inlets, and its rivers have bars at their mouths, but passing these, they are deep. One of them has been navigated by a Dutch steamer for about 300 miles. As yet only primary and secondary formations have been met with, but the mineral riches are very great. Diamonds, gold, iron, antimony, and coal are among its minerals; gums, gutta-percha, and all kinds of spices and tropical fruits, are among its vegetable productions.

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[1] Moniteur des Indes orientales, ii. p. 45.

Situate in the centre of a vast archipelago, and in the direct line of an extensive and valuable commerce, it will in the course of time become the seat of a great nation, whose civilization and prosperity will hand down to posterity the name of the late enterprising, philanthropic Sir James Brooke, Rajah of Saráwak, with the highest honour to which man can aspire. The climate is healthy, tempered by sea-breezes, and in some parts it is even European; the small island of Labuan and the adjacent coasts of Borneo, being rich in coal, and situated in the route of steam-vessels between India and China, exercise a very great influence on the trade between Europe and the Celestial Empire, and on the civilization of the barbarous and piratical tribes of the Eastern Archipelago.

The little known and curiously shaped island of Celebes is free from volcanoes in its southern and central portions. The structure of the part of the island near Macassar is interesting. Limestone mountains rest on a basis of basalt, which occasionally forms low rounded hills between the more precipitous portions. Basalt is nearly always found in the rocky beds of the streams, and over a step of this rock, about 40 feet high, come the beautiful falls of the Maros River. The northern part of the island, called Minahasa, has groups of fine volcanic peaks 6000 or 7000 feet high. The country is very beautiful; "noble palms and tree-ferns, wooded hills and volcanic peaks, everywhere meet the eye." Large coffee plantations exist in the district, and the people, from being head-hunters, like the Dyaks, are rapidly adopting civilized habits. The beautiful lake of Tondano is found at an elevation of 2000 feet, and the villages round it enjoy a comparatively temperate climate. Hot springs and mud volcanoes exist not far from the lake, and earthquakes are very frequent.

The Malay Archipelago has an extent of more than 4000 miles from E. to W., and of about 1300 from N. to S. Its expanse is equal to that between the extreme W. of Europe and Central Asia. Borneo is three times the size of Britain, and New Guinea is still larger. Sumatra has an area about equal to that of Britain; Java, Luzon, and Celebes, are each about the size of Ireland. Eighteen other islands are each as large as Jamaica, and more than 100 are as large as the Isle of Wight. The climate is uniform, and, with the exceptions of Timor and the adjacent islands, the islands of the archipelago are clothed with forest from the sea-level to the tops of the highest mountain peaks. The dryness and peculiar vegetation of Timor are probably the results of the S.E. monsoon from Australia, which produces atmospheric conditions that make the vegetation and physical aspect of the adjacent islands resemble its own.

A shallow sea, under 50 fathoms, connects the great islands of Sumatra, Java, and Borneo, with the Asiatic continent; while another shallow sea connects New Guinea and some of the adjacent islands to Australia. The productions of the islands thus connected are similar, and in many cases identical with those of the adjacent mainlands. Between these regions extends a sea whose depth is nowhere less than 100 fathoms, and in this lie the Moluccas, Celebes, and the islands E. of Lombok to Timor. All the islands E. of Celebes and Lombok exhibit almost as close a resemblance to Australia and New Guinea in their natural productions as do the western islands to Asia. The islands of Bali and Lombok, closely approximated as they are, are the places where the two regions meet most nearly, but are yet perfectly distinct. Many of the islands of the Archipelago are hardly known; the interior of the greater number has scarcely been explored; so that they offer a wide field of discovery to the enterprising traveller, and they are now of easier access since the seas have been cleared of pirates by the exertions of Sir James Brooke and the officers of Her Majesty's Navy. The travels of Mr. A. R. Wallace have recently added much to our information with regard to this archipelago; and New Guinea, "the greatest *terra incognita* that still remains for the naturalist to explore," is about to be the subject of extensive research at the expense of the Dutch government.

CHAPTER XV.

CORAL FORMATIONS, VOLCANIC ACTION, AND EARTHQUAKES.

§ 1. Different kinds of coral formations; atolls or lagoon islands; encircling reefs; barrier reefs; coral reefs. § 2. Areas of subsidence and elevation in the bed of the Pacific. § 3. Volcanic islands; Banda and Sunda groups; Java; Sumatra; Japan, &c. § 4. Volcanic action on the Andean shore of the Pacific. § 5. Volcanic region of the Red Sea. § 6. Volcanic action on the great continent. § 7. Active volcanoes; number and general description. § 8. Earthquakes; localities subject to them; researches of Mr. Mallet; volcanic action in Great Britain. § 9. Probable causes of earthquakes; various kinds of earthquakes. § 10. Change in the level of land arising from earthquakes.

§ 1. IT is a singular circumstance, arising from the instability of the crust of the earth, that most of the smaller tropical pelagic islands in the Pacific and Indian Oceans are either volcanic or coralline; and it is a startling fact that in most cases where there are volcanoes the land is rising by slow and almost imperceptible degrees above the ocean, whereas there is every reason to believe that those vast spaces studded with coral islands or atolls are actually sinking below it, and have been so for ages.[1]

There are four different kinds of coral formations in the Pacific and Indian Oceans, all entirely produced by the growth of organic beings, and their detritus; namely, lagoon islands or atolls, encircling reefs, barrier reefs, and coral fringes. They are all nearly confined to the tropical zones; the atolls to the Pacific and Indian Oceans alone.

An atoll or lagoon island consists of a chaplet or ring of coral, enclosing a lagoon or portion of the ocean in its centre. The average breadth of the part of the ring above the surface of the sea is about a quarter of a mile, oftener less, and it seldom rises higher than from 6 to 10 or 12 feet above the waves. Hence the lagoon islands are not discernible, even at a very small distance, unless when they are covered with the coco-nut palm, or the pandanus, as is frequently the case. On the outer side this ring or circlet shelves down to the distance of 100 or 200 yards from its edge, so that the sea gradually deepens to 25 fathoms, beyond which the sides plunge at once into the unfathomable depths of the ocean, with a more rapid descent than the cone of any volcano. Even at the small distance of some hundred yards no bottom has been found with a sounding-line a mile and a half long. All the coral below the surface of the water is alive—all above is dead, being the detritus of the living part, washed up by the surf, which is so heavy on the windward side of the tropical islands of the Pacific and Indian Oceans that it is often heard miles off, and is frequently the first warning to seamen of their approach to an atoll.

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[1] Mr. Darwin on Coral Reefs.

On the lagoon side, where the water is calm, the bounding ring or reef shelves into it by a succession of ledges, also of living coral, though not of the same species with those which build the exterior wall and the foundations of the whole ring. The perpetual change of water brought into contact with the external coral by the breakers probably supplies them with more food than they could obtain in a quieter sea, which may account for their more luxuriant growth. At the same time, they deprive the whole of the coral in the interior of the most nourishing part of their food, because the still water in the lagoon, being supplied from the exterior by openings in the ring, ceases to produce the hardier corals; and species of more delicate forms, and of much slower growth, take their place. The depth of the lagoon varies, in different atolls, from 20 to 50 fathoms, the bottom being partly detritus and partly live coral. By the growth of the coral some few of the lagoons have been filled up; but the process is very slow from the causes above assigned, and also because there are marine animals that feed on the living coral, and prevent its indefinite growth. In all departments of nature the exuberant increase of any one class is checked and limited by others. The coral is of the most varied and delicate structure, and of the most beautiful tints; dark brown, vivid green, rich purple, pink, deep blue, peach-colour, yellow, with dazzling white, contrasted with deep shadows, shine through the limpid water; while fish of the most gorgeous hues swim among the branching coral, which is of many different kinds, though all combine in the structure of these singular islands. Lagoon islands are sometimes circular, but more frequently oval or irregular in their form. Sometimes they are solitary, at other times in groups, but they occur most frequently in elongated archipelagos, with the atolls elongated in the same direction. The grouping of atolls bears a perfect analogy to the grouping of the archipelagos of ordinary islands.

The size of these fairy rings of the ocean varies from 2 to 90 miles in diameter, and islets are frequently formed on the submerged part of the coral rings by the washing up of the detritus, for they are so low that the waves break over them in high tides or storms.

They have openings or channels in their circuit, generally on the leeward side, where the tide enters, and by these ships may sail into the lagoons, which are excellent harbours, and even on the surface of the circlet or reef itself there are occasional boat-channels between the islets.

Dangerous Archipelago, lying E. of the Society Islands, is one of the most remarkable assemblages of atolls in the Pacific Ocean. There are 80, generally of a circular form, surrounding deep lagoons, and separated from each other by very deep channels. The reefs or rings are about half a mile across, and seldom rise more than 10 feet above the edge of the surf, which beats upon them with such violence that it may be heard at the distance of 8 miles; and yet on that side the coral insects build more vigorously, and vegetation thrives better, than on the other. Many of these islets are inhabited.

The Caroline Archipelago, the largest of all, lies N. of the equator, and extends its atolls in 60 groups over 1000 square miles. Many are of great size, and all are beat by a tempestuous sea and occasional hurricanes. The atolls in the Pacific Ocean and China Sea are beyond enumeration. Though less frequent in the Indian Ocean, none are more interesting, or afford more perfect specimens of this peculiar mode of formation, than the Maldive and Laccadive Archipelagos, both nearly parallel to the coast of Malabar, and elongated in that direction. The former is 470 miles long, and about 50 miles broad, with atolls arranged in a double row, separated by an unfathomable sea, into which their sides descend with more than ordinary rapidity. The largest atoll is 88 miles long, and somewhat less than 20 broad; Suadiva, the next in size, is 44 miles by 23, with a large lagoon in its centre, to which there is access by 42 openings. There are inhabited islets on most of the chaplets or rings not higher than 20 feet, while the reefs themselves are nowhere more than six feet above the water's edge.

The Laccadives are situated to the N. of the latter archipelago in a double line of nearly circular atolls, on which are low inhabited islets.

Encircling reefs differ in no respect from atoll-reefs, except that they have one or more islands within their lagoon. They commonly form a ring round mountainous islands, at a distance of two or three miles from the shore, rising on the outside from a very deep ocean, and separated from the land by a lagoon or channel 200 or 300 feet deep. These reefs surround the submarine base of the island, and, rising by a steep ascent to the surface, encircle the island itself. The Caroline Archipelago exhibits good examples of this structure in the encircled islands of Hogoleu and Siniavin; the narrow ring or encircling reef of the former is 135 miles in its very irregular circuit, on which are a vast number of islets; six or eight islands rise to a considerable height from its lagoon, which is so deep, and the opening to it so large, that a frigate might sail into it. The encircling reef of Siniavin is narrow and irregular, and its lagoon is so nearly filled by a lofty island that it leaves only a strip of water round it from two to five miles wide and 30 fathoms deep.

Tahiti, the largest of the Society Group, is another instance of an encircled island of the most beautiful kind; it rises in mountains 7000 feet high, with only a narrow plain along the shore, and, except where cleared for cultivation, it is covered with forests of coco-nut palms, bananas, bread-fruit, and other productions of a tropical climate. The lagoon which encompasses it like an enormous moat is 30 fathoms deep, and is hemmed in from the ocean by a coral band of the usual kind, at a distance varying from half a mile to three miles.

Barrier-reefs are of precisely the same structure as the two preceding classes, from which they only differ in their position with regard to the land. A barrier-reef off the N.E. coast of the continent of Australia is the grandest coral formation existing. Rising at once from an unfathomable ocean, it extends 1000 miles along the coast, with a breadth varying from 200 yards to a mile, and at an average distance of from 20 to 30 miles from the shore, increasing in some places to 60 and even 70 miles. The great arm of the sea included between it and the land is nowhere less than 10, occasionally 60 fathoms deep, and is safely navigable throughout its whole length, with a few transverse openings by which ships can enter. The reef is really 1200 miles long, because it stretches nearly across Torres Strait. It is interrupted off the southern coast of New Guinea by muddy water, probably from some great river on that island, which destroys the coral animals. There are also extensive barrier-reefs on the islands of La Louisiade and New Caledonia, which are exactly opposite to the great Australian reef; and as atolls stud that part of the Pacific which lies between them, it is called the Coralline Sea. The rolling of the billows along the great Australian reef has been admirably described. "The long ocean-swell, being suddenly impeded by this barrier, lifted itself in one great continuous ridge of deep blue water, which, curling over, fell on the edge of the reef in an unbroken cataract of dazzling white foam. Each line of breaker ran often one or two miles in length with not a perceptible gap in its continuity. There was a simple grandeur and display of power and beauty in this scene that rose even to sublimity. The unbroken roar of the surf, with its regular pulsation of thunder, as each succeeding swell fell first on the outer edge of the reef, was almost deafening, yet so deep-toned as not to interfere with the slightest nearer and sharper sound. . . . . Both the sound and sight were such as to impress the spectator with the consciousness of standing in the presence of an overwhelming majesty and power."[1]

Coral-reefs are distinct from all the foregoing: they are merely fringes of coral along the margin of a shore, and, as they line the shore itself, they have no lagoons. A vast extent of coast, both on the continents and islands, is fringed by these reefs, and, as they frequently surround shoals, they are very dangerous.

Lagoon islands are the work of various species of coral animals; but those particular zoophytes which build the external wall, the foundation and support of the whole ring or reef, are most vigorous when most exposed to the breakers; they cannot exist at a greater depth than 20 to 25 fathoms at most, and die immediately when left dry; yet the coral wall descends precipitously to unfathomable depths; and although the whole of it is not the work of these animals, yet the perpendicular thickness of the coral is known to be very great, extending hundreds of feet below the depth at which these polypi cease to live. From an extensive survey of the Coralline Seas of the tropics, Mr. Darwin has found an explanation of these singular phenomena in the instability of the crust of the earth.[2]

§ 2. Since there are certain proofs that large areas of the dry land are gradually rising, and others sinking down, so the bottom of the ocean is not exempt from the general change that is slowly bringing about a new state of things; and as there is evidence, on multitudes of the volcanic islands in the Pacific, of a rise in certain parts of the basis of the ocean, so the lagoon islands indicate a subsidence in others—changes arising from the expansion and contraction of the strata under the bed of the ocean.

There are strong reasons for believing that a continent once occupied a great part of the Pacific, within the tropics, some portion of which subsided by slow and imperceptible degrees. As parts of it gradually sank down below the surface of the deep, the tops of mountains and table-lands would remain as islands of different magnitude and elevation, and would form archipelagos elongated in the direction of the mountain-chains. Now, the coral animals, which construct the outward wall and mass of the reefs, never build laterally, and cannot exist at a greater depth than 20 to 25 fathoms. Hence, if they began to lay the foundation of a reef on the submerged flanks of an island, they would be obliged to build the wall upwards in proportion as the island sank down, so that at length a lagoon would be formed between it and the land. As the subsidence continued, the lagoon would increase, the island would diminish, and the base of the coral-reef would sink deeper and deeper, while the animals would always keep its top just below the surface of the ocean, till at length the island would entirely disappear, and a perfect atoll would be left. If the island were mountainous, each peak would form a separate island in the lagoon, and the encircled islands would have different forms, which the reefs would follow continuously. This theory explains perfectly the appearances of the lagoon islands and barrier-reefs, the continuity of the reef, the islands in the middle of the lagoons, the different distances of the reefs from them, and the forms of the archipelago, so exactly similar to the archipelagos of ordinary islands, all of which are but the tops of submerged mountain-chains, and generally partake of their elongated forms.[1]

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[1] By Mr. Jukes, Naturalist to the Surveying Voyage of Captain Blackwood, R.N., in Torres Strait.

[2] During the American dredging expedition between Florida and the N. of Cuba, live corals were found at such vast depths as will change the received opinions as to the depth at which reef-building corals may work, and will modify to a certain extent Darwin's theory of reefs, and their mode of growth.—*J. Gwyn Jeffreys, Esq.*

Every intermediate form between an atoll and an encircling reef exists: New Caledonia is a link between them. A reef runs along the north-western coast of that island 400 miles, and for many leagues never approaches within eight miles of its shore, the distance increases to 16 miles near the southern extremity. At the other end the reefs are continued on each side 150 miles beyond the submarine prolongation of the land, marking the former extent of the island. In the lagoon of Keeling Atoll, situate in the Indian Ocean, 600 miles S. of Sumatra, many fallen trees and a ruined store-house show that it has subsided: these movements took place during the earthquakes at Sumatra, which are also felt in this atoll. Violent earthquakes have been felt at Vanikoro (celebrated for the wreck of La Pérouse), a lofty island of the Queen Charlotte group, with an encircling reef in the western part of the South Pacific, and on which there are marks of recent subsidence. Other proofs are not wanting of this great movement in the beds of the Pacific and Indian Oceans.

The extent of the atoll formations, including under this name the encircling reefs, is enormous. In the Pacific, from the southern end of Low Archipelago to the northern extremity of Marshall Archipelago, a distance of 4500 miles, and many degrees of latitude in breadth, atolls alone rise above the ocean. The same may be said of the space in the Indian Ocean between Saya de Malha and the end of the Laccadives, which includes 25° of latitude—such are the enormous areas that have been, and probably still are, slowly subsiding. Other spaces of great extent may also be mentioned, as the large archipelago of the Carolinas, that in the Coralline Sea of the N.W. coast of Australia, and an extensive one in the China Sea.

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[1] Another theory relative to the formation of the lagoon islands is that the coral circuit is but the edge of a submarine elevation crater, on which the coral animals have raised their edifice. This view, which has been adopted by von Buch and Captain Beechey, to whom we are indebted more than to any other navigator for positive information and admirable surveys of the coral islands in the Pacific, receives corroboration from the perfect conformity in shape between many of the lagoon islands of the Gambier group and the known elevation craters, and from the circumstance of a lagoon island having been seen to rise in 1825, in lat. 30° 14′, accompanied with smoke, and communicating so high a temperature to the surrounding sea as rendered it impossible to land. See Beechey's 'Voyages' and Pöppig's 'Reise.'

§ 3. Though the volcanic islands in the Pacific are so numerous, there is not one within the areas mentioned, and there is not an active volcano within several hundred miles of an archipelago, or even group of atolls. This is the more interesting as recent shells and fringes of dead coral, found at the various heights on their surfaces, show that the volcanic islands have been rising more and more above the surface of the ocean for a very long time.

The volcanic islands also occupy particular zones in the Pacific, and it is found from extensive observation that all the points of eruption fall on the areas of elevation.[1]

One of the most terribly active of these zones begins in Morty Island, to the N.E. of Gilolo, extends southward through Gilolo, and thence by Ternate, Tidore, Makian, Batchian, Amboyna, Banda, the Serwatty Islands, Flores, Sumbawa, Lombok, Bali, Java, and Sumatra, separated only by narrow channels, and altogether forming a curved line 2000 miles long; but as the volcanic zone is continued through Barren Island and Narcondam, in the Bay of Bengal, northward through the islands along the coast of Aracan, the entire length of this volcanic range is a great deal more. During the last hundred years all the islands and rocks for 100 miles along the coast of Aracan have been gradually rising. The greatest elevation of 22 feet has taken place about the centre of the line of upheaval, in the N.W. end of the island of Cheduba, containing two mud volcanoes, and is continued through Foul Island and the Terribles.[2]

A violent volcanic eruption in 1646 rent open the island of Makian, and left a huge chasm which extended into the heart of the mountain. In 1860, the mountain was clothed with vegetation to its summit, and contained 12 populous villages. After 215 years of rest, the volcano burst forth again on December 29, 1862, altering the appearance of the mountain, destroying the inhabitants, and sending out such clouds of ashes that the air was darkened at Ternate, 40 miles off, and the growing crops of the adjacent islands were destroyed.

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[1] Few books have more interest than Mr. Darwin's on Coral Reefs and Volcanic Islands, to which the author is much indebted. Consult also the late Admiral Beechey's 'Voyages,' and his charts of the Coral Islands in the Pacific.

[2] By the Nautical Survey in 1848.

The little island of Gounong-Api, belonging to the Banda Group, contains a volcano of great activity; and such is the elevating pressure of the submarine fire in that part of the ocean that a mass of black basalt of such magnitude as to fill a bay 60 fathoms deep rose up so quietly that the inhabitants were not aware of what was going on till it was nearly done. Timor and the other adjacent islands also bear marks of recent elevation.

There is not a spot of its size on the face of the earth that contains so many volcanoes as the island of Java.[1] A range of volcanic mountains, from 5000 to 14,000 feet high, forms the central crest of the island, and ends to the E. in a series of 38 separate volcanoes with broad bases, rising gradually into cones. These volcanoes are chiefly arranged in two lines: one, beginning near Cape St. Nicholas, the north-western extremity of the island, runs diagonally across to the south-western headland on the Strait of Bali; the other, parallel to this, extends from the middle of the Strait of Sunda to the S. coast in the latitude of Cheribon. They all stand on a plain but little elevated above the sea, and each individual mountain seems to have been formed independently of the rest. Most of them are of great antiquity, and are covered with thick vegetation. Some are extinct, or only emit smoke; from others sulphureous vapours issue with prodigious violence; one has a large crater filled with boiling water; and a few have had fierce eruptions of late years. Regular lava streams never occur in Java. The island is covered with volcanic spurs from the main ridge, united by cross chains, together with other chains of less magnitude, but not less active.

In 1772 the greater part of one of the largest volcanic mountains was swallowed up after a short but severe combustion; a luminous cloud enveloped the mountain on the 11th of August, and soon after the huge mass actually disappeared under the earth with tremendous noise, carrying with it about 90 square miles of the surrounding country, 40 villages, and 2957 of their inhabitants.

The northern coast of Java is flat and swampy, but the southern provinces are beautiful and romantic; yet in the lovely peaceful valleys the stillness of night is disturbed by the deep roaring of the volcanoes, many of which are perpetually burning with slow but terrific action.

Java (with Madura) contains about 38,500 geographical square miles, an area nearly equal to that of England. The mountains are clothed to their summits with luxuriant vegetation; and their lower slopes are covered with forests and plantations. Above 8000 feet, many plants closely allied to those of Europe, are to be found. The tree-ferns of Java form a very distinguishing feature in its vegetation. Hundreds of square miles of country are under terrace cultivation; the country is thickly peopled; and scattered throughout the island, especially in the eastern part of it, there are to be found the remains of ancient cities, temples, tombs, and statues, which point to the existence of an advanced civilization, more than 400 years ago.

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[1] Sir Stamford Raffles on Java.

Separated from it by a narrow channel of the sea, Bali is but a continuation of Java, the same in nature and structure, but on a smaller scale, the mountains being little more than 8000 feet high.

Lombok and Sumbawa are alike in structure. They are mountainous and volcanic. The intensity of the volcanic force under this part of the Pacific may be imagined from the eruption of Tomboro in Sumbawa in 1815, which continued from the 5th of April till July. The explosions were heard at the distance of 970 miles; and in Java, at the distance of 300 miles, the darkness during the day was like that of deep midnight, from the quantity of ashes that filled the air: they were carried to Bencoolen, a distance of 1100 miles, which, with regard to distance, is as if the ashes of Vesuvius had fallen at Birmingham. The country round was ruined, and the town of Tomboro was submerged by heavy rollers from the ocean.

The mountains of Sumatra rise abruptly from its western coast. They extend for hundreds of miles in parallel ridges, varying in height from 2000 to 5000 feet; the highest peaks reaching an elevation of 8000 to 10,000 feet. The elevated longitudinal valleys, which are capable of irrigation and cultivation, are well peopled. The eastern side of Sumatra is flat and little elevated. The rivers wind through the level eastern plain, and form extensive deltas at their mouths. The most important of these is the Palembang River, which is navigable for 200 miles from its mouth. The country is covered with magnificent forests.

In Sumatra the extensive granitic formations of Eastern Asia join the volcanic series which occupies so large a portion of the Pacific. This most beautiful of islands presents the boldest aspect; it is indented by arms of the most transparent sea, and watered by innumerable streams; it displays in its vegetation all the bright colouring of the tropics. Here the submarine fire finds vent in three volcanoes on the southern, and one on the northern, side of the island. A few atolls, many hundreds of miles to the S., show that this volcanic zone alternates with an area of subsidence.

More to the N., and nearly parallel to the preceding zone, another line of volcanic islands begins to the N. of New Guinea, and passes through New Britain, New Ireland, Solomon Islands, and the New Hebrides, containing many open vents. This range or area of elevation separates the Coralline Sea from the great chain of atolls on the N. between Ellice Group and the Caroline Islands, so that it lies between two areas of subsidence.

The third and greatest of all the zones of volcanic islands begins in North Celebes, 200 miles to the westward of the first belt, and passes by Siau and Sanguir through the Philippine Islands and Formosa: bending thence to the N.E., it passes through Loo-Choo, the Japan Archipelago, and is continued by the Kurile Islands to the peninsula of Kamtchatka, where there are several volcanoes of great elevation.

The width of the volcanic belts in the Malay Archipelago is about 50 miles; but for a space of 200 on each side of them, there are evidences of subterranean action in recently elevated coral-rock, or in barrier coral-reefs, indicating recent submersion. Borneo, New Guinea, and the whole of Celebes, except the eastern end of its northern peninsula, are non-volcanic.

That long chain of volcanic islands which forms the empire of Japan was little known to Europeans until recently: the Dutch were the first Europeans who had any intercourse with them; the United States have a commercial treaty with them; and, as a result of treaties, six ports—Yeddo, Hakodate, Kanagawa, Nagasaki, Osaka, and Hiogo—are now open to the British; so that 40 millions of new people are brought into intercourse with Europe.

The Japanese islands, so far as they are known to Europeans, are mountainous, spurs of the principal ranges coming in places close to the sea; and hills being everywhere prominent features of the landscape. "All level ground in Japan," says Sir Rutherford Alcock, "would seem, indeed, but circumscribed plains or valleys of variable dimensions, in great contrast to the dead level and all but boundless plains of the great river courses of China." The mountain scenery is extremely picturesque, the hills being generally clothed to the summits with trees—many of them of the family of the pines; and their lower slopes are frequently cultivated in terraces. Much of the soil is exceedingly fertile, and within a hundred miles of Yeddo it consists exclusively of dark rich mould. Some of the mountainous districts show distinct evidences of the volcanic agency which is so active throughout the land; and the principal mountain, Fusiyama (Rich Scholar Peak), in the island of Nippon, is a volcano, whose latest recorded eruption was in 1707. Fusiyama was ascended by Sir Rutherford Alcock and his party. The flanks of the mountain are clothed with magnificent forests of oak, pine, and beech; but the ascent of the upper half of the mountain was over lava and scoriæ, getting more rough and precipitous as the summit was neared. The crater is a great oval opening, about 1100 yards in length, with a mean width of 600 and a depth of 350 yards. The estimated height of the crater above the sea-level was 13,977 feet, and that of the highest peak, 14,177 feet. Fusiyama is a sacred mountain, and is an object of pilgrimages, which are performed in July and August, the only months in which the mountain is sufficiently clear from snow to allow the ascent to be made. This great peak forms a fine object in the landscape, and can be seen from Yeddo. Earthquakes are extremely common, and one which took place in 1783 rivalled that of Lisbon in its destructiveness. Another in 1854 did much damage in Yeddo. Hot springs are common; those of Atami were visited by Sir R. Alcock. The Lake Hakoni, a fine sheet of water surrounded by hills, and situated at an elevation of 6250 feet above the sea-level, lies N. of Fusiyama in a beautiful and secluded spot. The Japanese are skilful agriculturists and gardeners. Much grain, particularly rice, is grown; and great care is bestowed on the cultivation of flowers, for which the people have a passion. Many new plants have lately been introduced into this country from Japan. The Japanese are dexterous manufacturers in the metals, are clever draughtsmen, and make excellent maps of their country. The country is rich, and the people are industrious and laborious, clean, neat, and orderly.

There are six islands E. of Jephoon in the Japan Archipelago, which are subject to eruptions, and the internal fire breaks through the Kurile Islands in 18 vents, besides having raised two new islands in the beginning of this century, one four miles round, and the other 3000 feet high, though the sea there is so deep that the bottom has not been reached with a line 200 fathoms long.

Thus some long rent in the earth has extended from the tropics to the gelid seas of Okhotsk and the peninsula of Kamtchatka: a new one begins to the E. of the latter in the Aleutian Islands, which are of the most barren and desolate aspect, perpetually beaten by the surge of a restless ocean, and bristled by the cones of 24 volcanoes; they sweep in a half-moon round Behring Sea till they join the volcanic peninsula of Aliaska.

The line of volcanic agency has been followed far beyond the limits of the coral-working animals, which extend but a short way on each side of the tropics; but it has been shown that in the equatorial regions immense areas of elevation alternate with as great areas of subsidence: N. of Australia they are so mixed that a point of convergence is indicated.[1]

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[1] Darwin on Volcanic Islands.

§ 4. On the other side of the Pacific the whole chain of the Andes, and the adjacent islands of Juan Fernandez and the Galapagos, form a vast volcanic area, which is actually now rising; and though there are few volcanic islands N. of the zone of atolls, yet those that be indicate great internal activity, especially in the Sandwich Islands, where the volcanoes of Hawaii are inferior to none in awful sublimity. That of Kilauea (3970 feet above the sea), a lateral crater of eruption of the great central volcano of Mauna Loa, was seen in high activity by Mr. Douglas in 1834, subsequently by Mr. Dana, and in March and April, 1868, it vomited forth torrents of lava which devastated the southern part of the island. During this last eruption the floor of the crater sank some hundreds of feet and the column of smoke was visible at Lahaina, 120 miles distant. The crater is more than three miles in diameter, formed of solidified lava. It was 990 feet deep in 1851; the bottom filled by a lake of liquid lava, in furious ebullition, occasionally spouting to the height of from 20 to 70 feet, whence streams of lava, hurrying along in fiery waves, were finally precipitated down an ignited arch, where the force of the lava was partly arrested by the escape of gases, which threw back huge blocks and literally spun them into threads of glass, which were carried by the wind like the refuse of a flax-mill. Mr. Douglas says the noise could hardly be described—that of all the steam-engines in the world would be a whisper to it; and the heat was so overpowering, and the dryness of the air so intense, that the very eyelids felt scorched and dried up.[1]

There are great volcanic mountains in Hawaii: Rohala, 9800 feet—Mauna Kea, 13,953—Hualalai, 11,020—and Mauna Loa, 13,758—above the sea.

The Pacific, which contains various volcanic areas of vast extent and intense energy, is itself the most magnificent volcanic basin on the globe. Beginning at Graham's Land in the Antarctic Ocean, it passes to the volcanoes in Tierra del Fuego, along the chain of the Andes, the Central American and Mexican volcanoes, and the scattered chain of volcanoes along the W. coast of N. America, to Mount St. Elias, in 60° N. at the northern extremity of the Pacific. From Mount St. Elias there is an almost unbroken line of mountain and volcano in the Aleutian Archipelago, carried down through the great elevated peninsula of Kamtchatka, the Kurile Isles, Jesso, Japan, the Philippines, and to the N. of New Guinea, by its volcanoes and those of New Britain, the Solomon Isles, Egmont, New Hebrides, New Caledonia, and New Zealand, to the Antarctic ice again, at the Balleny Islands and Buckle Volcano, possibly to

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[1] Mr. Douglas's Voyage to the Sandwich Islands in 1833-4.—'Journal of the Royal Geographical Society of London,' 1855.

Victoria Land. In this enormous circuit the elevated ridge of the basin is of vast altitude on the American continent; but on the other side the ridge is frequently subaqueous, only rising into heights at intervals, though probably continuous throughout.

§ 5. At the head of the Red Sea, between the 12th and 16th parallels of N. lat., there is a volcanic region covering an area of 10,000 square miles without interruption, which is perhaps the third or fourth in extent on the surface of the earth. The Jebel-Tear is still smoking, and one of the Zugar Islands was in eruption in 1846. The volcano of Aden has been submerged and elevated again since the last period of its activity.[1]

It may be observed that, where there are coral fringes, the land is either rising or stationary; for, were it subsiding, lagoons would be formed. On the contrary, there are many fringing reefs on the shores of volcanic islands along the coasts of the Red Sea, the Persian Gulf, and the West Indian Islands, all of which are rising. Indeed this occurrence, in numberless instances, coincides with the existence of upraised organic remains on the land.

As the only coral formations in the Atlantic are fringing reefs, and as there is not one in its central expanse, except in Bermuda, it may be concluded that the bed of the ocean is not sinking; and with the exception of the Leeward Islands, the Canaries, the Azores, and the Cape de Verd groups, there are no active volcanoes in the islands or on the coasts of that ocean.

§ 6. At present the great continent has few centres of volcanic action in comparison with what it once had. The Mediterranean is still undermined by fire, which occasionally finds vent in Vesuvius and the stately cone of Etna. Though Stromboli constantly pours forth inexhaustible showers of incandescent matter, and a temporary island now and then starts up from the sea, the volcanic action has not diminished: Vesuvius has been several times in eruption within the last few years, the eruption of December, 1861, having nearly destroyed the populous town of Torre del Greco, for the second time in a century; and the activity of the mountain having been great ever since (1869).

The table-land of Western Asia, especially Azerbijan, has once been the seat of intense commotion, now spent, as evidenced by the volcanic peaks of the Seiban Dagh, Ararat, and by the still smoking cone of Demavend.

The range of the Tian-Shan, or Celestial Mountains, supposed by Humboldt to be volcanic, have been shown by the actual research of M. Semenof to have no volcanoes, and to be destitute of typical volcanic phenomena and even of volcanic forms. Sulphur has been found issuing from some fissures in the form of vapour, but this may be accounted for by the combustion of some of the numerous coal-seams that exist in the basin of the Ili River, which rises in the Tian-Shan, and flows N.W. into Lake Balkash. In the range of Tarbagatai, in the country of the Kirghiz, there is a mountain said to emit smoke and even flame, which produces sulphur and salammoniac in abundance. The group of hot springs near the salt lake Kiook-Kiul and the valley of the Nubra, discovered by the brothers Schlagintweit, in 1856, during a journey from Ladak to Khotan across the Karakorum chain, shows that volcanic action still exists to the S. of the Tian-Shan, and that the Karakorum is probably a volcanic formation, as was suspected by Humboldt. These gentlemen were the first Europeans who crossed that mighty chain of Central Asia, which is so lofty that some of the peaks they measured were 24,000 feet high. It is not ascertained that there are any mountains in China that eject lava, but there are many fire-hills and fire-springs; the latter are real Artesian wells, five or six inches wide and from 1500 to 3000 feet deep: from some of these, water rises containing a great quantity of common salt; from others gases issue: and when a flame is applied, fire rushes out with great violence, rising 20 or 30 feet high, with a noise like thunder. The gas, conducted in tubes of bamboo cane, is used in the evaporation of salt water from the neighbouring springs.

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[1] Dr. Buist.

§ 7. There are altogether about 270 active volcanoes, of which 190 are on the shores and islands of the Pacific.[1] They are generally disposed in lines or groups. The chain of the Andes furnishes a magnificent example of linear volcanoes. The Peak of Teneriffe, encompassed by the volcanic islands of Palma and Lancerote, is an equally good specimen of a central group. Eruptions are much more frequent in low than in the more elevated volcanoes; that in the island of Stromboli is in constant activity; whereas Cotopaxi, 18,875 feet high, and Tunguragua, 16,424, in the Andes, have only been active once in a hundred years. On account of the force requisite to raise lava to such great elevations, it rarely flows from very elevated cones. Antisana is the only instance to the contrary among all the lofty volcanoes of Equatorial America. In Etna, as in the volcano of Hawaii also, the pressure is so great that the lava forces its way through the sides of the mountain, or at the base of the cone. The same generally happens in Vesuvius, the great lava eruptions being chiefly from the base of the cone.

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[1] "The number of active volcanoes on sea-coasts and in islands is probably connected with the agency of water in volcanic operations. The latest chemical observations on the products of recent eruptions favour the doctrine that large bodies of salt-water gain access to the volcanic foci." Steam or aqueous vapour may propel lava to the surface; and "various gases, rendered liquid by pressure at great depths, may aid in causing volcanic outbursts, and in fissuring and convulsing the rocks during earthquakes."—Lyell's 'Principles of Geology,' 10th edition, 1868.

An eruption begins by a dense volume of smoke issuing from the crater, mixed with aqueous vapour and gases; then masses of rock and molten matter in a half-fluid state are ejected with tremendous explosion and violence; after which lava begins to flow, and the whole terminates by a shower of ashes from the crater—often the most formidable part of the phenomenon, as was experienced at the destruction of Pompeii. There are several volcanoes which eject only streams of boiling water, as the Volcano de Agua in Guatemala; others pour forth boiling mud, as in the islands of Trinidad, Java, and Cheduba in the Bay of Bengal. A more feeble effort of the volcanic force appears in the numerous solfataras. Hot springs show that the volcanic fire is not extinguished, though not otherwise apparent. To these may be added the emanations of boracic acid, in a gaseous form, acidulous springs, those of naphtha, petroleum, and various kinds of gas, as carbonic acid, the food of plants—and, when breathed, the destruction of animals, as is fearfully seen in the Guevo Upas, or "Valley of Death," in Java: it is half a mile in circumference and about 35 feet deep, with a few large stones and not a vestige of vegetation on the bottom, which is covered with the skeletons of human beings and the bones of animals and birds blanched white as ivory. On approaching the edge of the valley, which is situate on the top of a hill, a nauseous sickening sensation is felt, and nothing that has life can enter its precincts without being immediately suffocated.[1]

The seats of activity have been perpetually changing, but there always has been volcanic action, possibly more intense in former times; but even at present it extends from pole to pole.

§ 8. Notwithstanding the numerous volcanic vents in the globe, many places are subject to violent earthquakes, which destroy the works of man and often change the configuration of the country. The most extensive district of earthquakes comprises the Mediterranean and the adjacent countries, Asia Minor, the Caspian Sea, Caucasus, and the Persian mountains. A great part of the continent of Asia is more or less subject to shocks; but with the exception of the shores of the Red Sea and the northern parts of Barbary, Africa is entirely free from these tremendous scourges; and it is singular that, notwithstanding the terrible earthquakes which shake the countries west of the Andes, the Andean chain itself, and all the countries round the Gulf of Mexico and the

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[1] Letter from Alex. Loudon, Esq., in the 'Journal of the Geographical Society of London.'

Caribbean Sea, they are extremely rare in the great eastern plains of South America. Greenland, Spitzbergen, and great part of Australia also seem to enjoy an immunity from the attacks of earthquakes. For the most part the shocks are transmitted in the line of the primary mountain-chains, and seem often to be limited by them in the other direction. The estuaries of the Indus and Ganges, the coasts of Siam and Eastern China, constitute a depressed continental earthquake range. The Pyrenees, Apennines, Balkan, and Caucasus, are all points of intensity on a line of mountains interrupted by seas and broad valleys. The great centres of earthquake in Europe are actively volcanic—Hecla, Vesuvius, Etna, and Santorin.

Mr. Mallet, in his most interesting work on earthquakes, mentions that the Scandinavian peninsula is so connected with Iceland by the bed of the Northern Ocean that no marked convulsion happens in the one without being felt in the other. "Scandinavia, itself one of the most remarkable masses of land in slow process of elevation, also shows its connection with internal action; and were it not that Iceland is pierced with numberless vents, broken and shattered in every direction by volcanic action that admits of no cessation or consolidation above, there can be no doubt that the destructive power of earthquakes would be manifested in the northern peninsula to a far more serious extent and intensity."

There must be some singular volcanic action connected with Great Britain which has occasioned 255 slight shocks of earthquake, of which 139 took place in Scotland, the most violent of them having been felt at Comrie, in Perthshire, in 1839; of the rest 14 took place on the borders of Yorkshire and Derbyshire, 30 in Wales, and 31 on the S. coast of England. Mr. Mallet ascertained that the direction of the wave of shock of the earthquake that happened in November, 1852, was inclined to the horizon at an angle of 25° or 30°; and assuming the origin to have been even somewhere between Great Britain and Lisbon, the depth of the focus must have been very great; that earthquake extended over the greater portion of the British Isles, the maximum disturbance on the surface being about Shropshire. The mean direction of the British earthquakes probably passes through the focus of the Lisbon earthquakes and that of the Canary Islands.

§ 9. Earthquakes, like volcanoes, are the result of the development of heat and chemical action at various depths in the interior of the globe. Fractures and sudden heavings and subsidences in the flexible crust of the globe result from the pressure of the liquid matter, vapour, and gases, in its interior. "The flexibility of certain parts of the earth's crust, as deduced from observations on earthquakes, may imply the continuous existence of vast reservoirs of melted matter beneath the surface, but such nevertheless as might hold a very subordinate place in the earth's crust."[1] But whether the initial impulse be eruptive, or a sudden pressure upwards, the shock originating in that point is propagated through the elastic surface of the earth in a series of circular or oval undulations, similar to those produced by dropping a stone into a pool, and like them they become broader and lower as the distance increases, till they gradually subside; in this manner the shock travels through the land, becoming weaker and weaker till it terminates. When the impulse begins in the interior of a continent, the elastic wave is propagated through the solid crust of the earth, as sound is through the air, and is transmitted from the former to the ocean, where it is finally spent and lost, or, if very powerful, is continued in the opposite land. In 1854, when the town of Yeddo was engulfed, and a Russian frigate wrecked, by the tremendous waves that repeatedly rolled on the beach of the island during a great earthquake, remarkable waves were recorded to have been observed on the coast of California a few hours afterwards. The earthquake of 1868, which was so destructive in Peru and Ecuador, ruined the strip of land at the western foot of the Andes, from Iburra, in Ecuador, to Iquique, in Peru, 1200 miles in length, levelled to the ground the cities of Arequipa, Iquique, Arica, and Pasco, destroying property of the worth of 60,000,000 of pounds, and 20,000 lives. The earth opened in all the plains round Arequipa, old volcanoes burst forth, and where Cotacachi stood is now a lake. The wave which was seen from Arica to roll in and strike the mole to pieces came probably from a line in the sea parallel to the coast, where the most violent subterranean disturbance happened. From this tract as a centre the shock was propagated in all directions: to Australia, New Zealand, the Sandwich Islands, and California; passing in its course over one-fourth of the circuit—6500 miles by measure—and covering in surface one-eighth of the area of the globe. At Arica and Iquique the earthquake was observed on the 13th of August at 5 P.M; the water-wave was felt at Chatham Islands on the 15th between 1 and 2 A.M., and on the coast of New Zealand at 3 or 4 A.M; at Sydney it occurred at 2·30 A.M.; at Hilo, in the Sandwich Islands, it was felt on the 14th, 15th, and 16th; and at San Pedro, on the Californian coast, on the 15th. The velocity of the water-wave in a minute was above 6¾ miles, and in an hour above 400 miles. Many of the great earthquakes, however, have their origin beneath the bed of the ocean, far from land, whence the shocks extend in undulations to the surrounding shores.

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[1] Lyell's 'Principles of Geology,' 10th edition, 1868.

From observations of earthquakes recorded as being felt at sea, a great submarine active volcanic area, first noticed by M. Daussy, is believed to exist in the bed of the Atlantic, nearly midway between Cape Palmas on the west coast of Africa and Cape San Roque on the coast of Brazil. This vast disturbed and perhaps partially igneous ocean-floor can be no less than 9° in length from W. to E., and from 3° to 4° in breadth from N. to S. Within this area, equal in size to Great Britain, ships have been violently shaken, so that the crew thought they had struck on a rock, but on sounding found deep water: noises have been heard, tremblings felt; and on one occasion volcanic ashes or cinders were found on the surface of the sea when much agitated. This is an object of such high geological interest as to be worthy of being investigated by deep-sea sounding.

No doubt many shocks of small intensity are imperceptible: it is only the violent efforts of the internal forces that can overcome the pressure of the ocean's bed, and that of the superincumbent water. The internal pressure is supposed to find relief most readily in a belt of great breadth that surrounds the land at a considerable distance from the coast, and, being formed of débris, the internal temperature is in a perpetual state of fluctuation, which would seem to give rise to sudden flexures and submarine eruptions.

When the original impulse is a fracture or eruption of lava in the bed of the deep ocean, two kinds of waves or undulations are produced and propagated simultaneously—one through the bed of the ocean, which is the true earthquake shock; and coincident with this a wave is formed and propagated on the surface of the ocean, which rolls to the shore, and reaches it in time to complete the destruction long after the shock or wave through the solid ocean-bed has arrived and spent itself on the land. The sea rose 50 feet at Lisbon and 60 at Cadiz after the great earthquake; it rose and fell 18 times at Tangier on the coast of Africa, and 15 times at Funchal in Madeira. At Kinsale a body of water rushed into the harbour, and the water in Loch Lomond in Scotland rose two feet four inches—so extensive was the oceanic wave.[1] The height to which the surface of the ground is elevated, or the vertical height of the shock-wave, varies from one inch to two or three feet. This earth-wave, on passing under deep water, is imperceptible, but when it comes to soundings, it carries with it to the land a long, flat, aqueous wave; on arriving at the beach, the water drops in arrear from the superior velocity of the shock, so that at that moment the sea seems to recede before the great ocean-wave arrives.

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[1] Mitchell on the Causes of Earthquakes, in Philosophical Transactions for 1760.

It is the small forced wave that gives the shock to ships, and not the great one; but when ships are struck in very deep water, the centre of disturbance is either immediately under, or very nearly under, the vessel.

Three other series of undulations are formed simultaneously with the preceding, by which the sound of the explosion is conveyed through the earth, the ocean, and the air, with different velocities. That through the earth travels at the rate of from 7000 to 10,000 feet in a second in hard rock, somewhat less in looser materials, and arrives at the coast a short time before, or at the same moment with, the shock, and produces the hollow sounds that are the harbingers of ruin; then follows a continuous succession of sounds like the rolling of distant thunder, formed, first, by the noise propagated in undulations through the water of the sea, which travels at the rate of 4700 feet in a second, and, lastly, by that passing through the air, which only takes place when the origin of the earthquake is a submarine explosion, and travels with a velocity of 1123 feet in a second. The rolling sounds precede the arrival of the great oceanic wave on the coasts, and are continued after the terrific catastrophe when the eruption is extensive.[1]

When there is a succession of shocks, all the phenomena are repeated. Sounds sometimes occur when there is no earthquake: they were heard on the plains of the Apure, in Venezuela, at the moment the volcano in St. Vincent's, 700 miles off, discharged a stream of lava. The bellowings of Guanaxuato afford a singular instance: these subterranean noises have been heard for a month uninterruptedly when there was no earthquake felt on the table-land of Mexico, nor in the rich silver-mines 1600 feet below its surface.

The velocity of the great oceanic wave varies as the square-root of the depth; it consequently has a rapid progress through deep water, and less when it reaches to soundings. That raised during the earthquake at Lisbon travelled to Barbadoes at the rate of 7·8 miles, and to Portsmouth at the rate of little more than two miles in a minute. The velocity of the shock varies with the elasticity of the strata it passes through. The undulations of the earth are subject to the same laws as those of light and sound; so, when the shock or earth-wave passes through strata of different elasticity, it will be partly reflected, and a wave will be sent back, producing a shock in a contrary direction, and partly refracted, or its course changed, so that shocks will occur both upwards and downwards, to the right or to the left of the original line of transit. Hence most damage is done at the junction of deep alluvial plains with the hard strata of the mountains, as in the great earthquake in Calabria in the year 1783.

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[1] Thus, when an earthquake begins under the ocean, it occasions five distinct series of waves or undulations, all of which are subject to the same laws of motion, namely, the earth-wave, the water-wave, and three other series of waves arising from the passage of the sound of the explosion through the air, the earth, and the water. For the laws of Sound, see 'Connexion of the Physical Sciences,' 8th edition.

When the height of the undulations is small, the earthquake will be a horizontal motion, which is the least destructive; when the height is great, the central and horizontal motions are combined, and the effect is terrible. The concussion was upwards in the earthquake which took place at Riobamba in 1797. Baron Humboldt mentions that some of the inhabitants were thrown across a river, several hundred feet in height, on a neighbouring mountain. The worst of all is a verticose or twisting motion, which nothing can resist; it is occasioned by the crossing of two waves of horizontal vibration, which unite at their point of intersection, and form a rotatory movement. This, and the interferences of shocks arriving at the same point from different origins or routes of different length, account for the repose in some places, and those extraordinary phenomena that took place during the earthquake of 1783 in Calabria, where the shock diverged on all sides from a centre through a highly elastic base covered with alluvial soil, which was tossed about in every direction. The dynamics of earthquakes have been ably discussed by Mr. Mallet in a very interesting paper in the 'Transactions of the Royal Irish Academy.'

There are few places where the earth is long at rest, for, independently of those secular elevations and subsidences that are in progress over such extensive tracts of country, small earthquake shocks must be much more frequent than we imagine, though imperceptible to our senses, and only to be detected by means of instruments. The shock of an earthquake at Lyons in February, 1822, was not generally perceptible at Paris, yet the wave reached and passed under that city, and was detected by the oscillation of the large declination needle at the Observatory, which had previously been at rest.

The undulations of some of the great earthquakes have spread to an enormous extent. The movement of the earthquake of 1868, which has been referred to, was felt from 8° S. to 42° S., and at Juan Fernandez. The earthquake that happened in 1842 in Guadaloupe was felt over an extent of 3000 miles in length; and that which destroyed Lisbon had its origin in the bed of the Atlantic, from whence shocks extended over an area of about 700,000 square miles, or a twelfth part of the circumference of the globe: the West Indian Islands, and the lakes in Scotland, Norway, and Sweden, were agitated by it. In linear distance the effects of that earthquake extended through 300 miles, the shocks were felt through a line of 2700 miles, and the vibrations or tremors were perceptible in water through 4000 miles. It began without warning, and in five minutes the city was a heap of ruins.

The earthquake of Calabria, in 1783, which completely changed the face of the country, only lasted two minutes; it was not very extensive, yet all the towns and villages for 22 miles round the small town of Oppido were utterly ruined. The destruction is generally accomplished in a fearfully short time: the earthquake at Caraccas, in March, 1812, consisted of three shocks, which lasted three or four seconds, separated by such short intervals that in 50 seconds 10,000 people perished. Baron Humboldt's works are full of interesting details on this subject, especially with regard to the tremendous convulsions in South America.

Sometimes a shock has been perceived underground which was not felt at the surface, as in the year 1802, in the silver-mine of Marienberg, in the Harz. In some instances miners have been insensible to shocks felt on the surface above, which happened at Fahlun, in Sweden, in 1823—circumstances in both instances depending on the elasticity of the strata, the depth of the impulses, or obstacles that may have changed the course of the terrestrial undulation. During earthquakes, dislocations of strata take place, the course of rivers is changed, and in some instances they have been permanently dried up; rocks are hurled down, masses raised up, and the configuration of the country altered; but if there be no fracture at the point of original impulse, there will be no noise.

§ 10. The power of the earthquake in raising and depressing the land has long been well known, but the gradual and almost imperceptible change of level through immense tracts of the globe is altogether a recent discovery; it has been ascribed to the expansion of rocks by heat, and subsequent contraction by the retreat of the melted matter from below them. It is not at all improbable that there may be motions, like tides, ebbing and flowing, in the internal lava, for the changes are by no means confined to those enormous elevations and subsidences that appear to be in progress in the basin of the Pacific and its coasts, nor to the Andes and the great plains E. of them—countries for the most part subject to earthquakes; they take place to a vast extent in regions where these convulsions are unknown. There seems to be an extraordinary flexibility in the crust of the globe from the 54th or 55th parallel of N. latitude to the Arctic Ocean. There is a line crossing Sweden from E. to W. in the parallel of 56° 3′ N. lat. along which the ground is perfectly stable, and has been so for centuries. To the N. of it for 1000 miles, between Gottenburg and North Cape, the ground is rising; the maximum elevation, which takes place at North Cape, being at the rate of five feet in a century. At Gefle, 90 miles N.

of Stockholm, it is about two or three feet in a century, and from thence it gradually diminishes to six inches in a century at Stockholm. S. of the line of stability, on the contrary, the land is sinking through part of Christianstad and Malmo, for the village of Stassten, in Scania, is now 380 feet nearer to the Baltic than it was in the time of Linnæus, more than 100 years ago, by whom it was measured. The coast of Denmark on the Sound; the island of Saltholm, opposite to Copenhagen; and that of Bornholm, are rising, the latter at the rate of a foot in a century. The coast of Memel on the Baltic has actually risen a foot and four inches within the last 40 years, while the coast of Pillau has sunk down an inch and a half in the same period. The W. coast of Denmark, part of the Faröe Islands, and the W. coast of Greenland, are all being depressed below their former level. In Greenland the encroachment of the sea, in consequence of the change of level, has submerged ancient buildings on the low rocky islands and on the mainland. The Greenlander never builds near the sea on that account, and the Moravian settlers have had to move inland the poles to which they moor their boats. It has been in progress for four centuries, and extends through 600 miles from Igalito Firth to Disco Bay.[1] Mr Robert Chambers has shown that in our own country the land has been for ages on the rise, and that the parallel roads in Glen Roy, which have so long afforded matter of discussion, are merely margins left by the retreat of the water, as the land alternately rose and remained stationary. In the present day the elevation is going on in many places, especially on the Moray Firth and in the Channel Islands. The notice of this curious subject of the gradual changes of level in the land has been chiefly revived by Sir Charles Lyell, in whose very instructive works on geology all the details will be found.[2]

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[1] Captain Graah's Survey in 1823-4, and Dr. Pingel, 1830-2.

[2] Lyell's 'Principles of Geology.' See also Mr. Darwin's observations on the same subject, in the 'Voyage of the Adventure and Beagle;' M. Domeyko, 'Sur les Lignes d'ancien Niveau de l'Ocean du Sud, aux Environs de Coquimbo,' Annales des Mines, 1848; and for an illustration of the whole of this chapter, the maps of active volcanoes, of volcanic phenomena, and earthquakes, in Keith Johnston's Physical Atlases.

CHAPTER XVI.

THE ARCTIC AND ANTARCTIC REGIONS.

§ 1. Arctic lands. § 2. Greenland. § 3. Spitzbergen; temperature of the Arctic regions. § 4. Iceland; plain of ice; volcanic phenomena; the Geysers; fiords; climate; islands of Jan Mayen and New Siberia. § 5. Antarctic lands; Victoria continent; Mount Erebus; ice-bound character of the coast.

§ 1. THE continent of North America seems to have been much shattered and broken up by the Polar Ocean into a vast number of fragments of great size, all bearing more or less the severe character of Arctic lands. It may be that the land is sinking down or rising up, for in either case appearances would be the same, but the climate would improve in the first, and would be, if possible, more rigorous in the second. Immediately to the N. of the continent land of great extent lies between 69° and 75° N. lat., and stretching nearly from the 60th to the 125th degree of W. longitude. On the S. this mass of land is separated from the continent by various narrow straits, Dolphin, Union, and Dease Straits. The Arctic Ocean bounds it on the W.; the straits of Banks, Melville, and Barrow, with Lancaster Sound, on the N.; and its eastern limits are Davis Strait and Hudson Bay. It is divided into three parts by Prince Regent Inlet and the Gulf of Boothia on the one hand, and by Prince of Wales Strait on the other. The eastern part, known as Cockburn Island, is intersected by various arms of the sea, respecting which little is known. The middle part contains Boothia, Victoria, Wollaston, and Prince Albert Lands. Banks Island is the westerly continuation; its northern coast was discovered by Sir Edward Parry, who gave it the name of Banks; and Captain M'Clure, in his voyage from Behring Strait, first discovered its most southerly point, Prince of Wales Strait, which separates it from Prince Albert Land, and afterwards all but circumnavigated the island. Besides these three principal parts, North Somerset Island, lying immediately S. of Barrow Strait, forms a northern continuation of Boothia, only separated from it by the narrow passage called Bellot Strait.

N. of that long line of narrow seas or straits, already mentioned, that stretches from Banks Island to Baffin Bay, lie Prince Patrick, Melville, Byam Martin, Bathurst, and Cornwallis Islands, celebrated in the annals of Arctic discovery as Parry Lands. Beyond this is the great oceanic inlet of Wellington Channel, formerly the object of so much Arctic research, and forming its eastern side. The great island of North Devon lies more to the E., and ends in Baffin Bay; on the N. it is divided by Jones Sound from North Lincoln and Ellesmere Island, which has been traced as far as Victoria Head, in 78° 28′ 21″ N. lat., by Captain Inglefield, who discovered that it is separated from Greenland by Smith Sound, and who supposed that the latter is a strait leading from Baffin Bay into the Polar Ocean. A glimpse of the supposed open Polar Sea in this direction was obtained by Morton in Dr. Kane's celebrated expedition; afterwards Dr. Hayes reached a higher point in the strait and confirmed this important discovery. It is by Smith Sound that Captain Sherard Osborn advocates an attempt being made to reach the Pole itself, by sledging along the coast or across the ice in spring.

§ 2. Greenland, the most extensive of the Arctic lands, begins with the lofty promontory of Cape Farewell, the southern extremity of a group of rocky islands, which are separated by a channel five miles wide from a table-land of appalling aspect, narrow to the S., but increasing in breadth northward to a distance of which only 1300 miles are known. This table-land is bounded by mountains rising from the deep in mural precipices, which terminate in needles and pyramids, or in parallel terraces, of alternate snow and bare rock, occasionally leaving a narrow shore. The coating of ice is so continuous and thick that the surface of the table-land may be regarded as one enormous field of ice, which overlaps the rocky edges 2000 feet high, and dips in icy platforms through the fiords between the mountain-peaks into the sea.

The coasts are beset with rocky islands, and cloven by fiords, which in some instances wind like rivers for 100 miles into the interior. These deep inlets of the sea, now sparkling in sunshine, now shaded in gloom, are hemmed in by walls of rock often 2000 feet high, whose summits are hid in the clouds. They generally terminate in glaciers, which are forced on by the pressure of the upper ice-plains till they fill the fiord, and even project far into the sea like bold headlands, when, undermined by the surge, huge masses of ice fall from them with a crash like thunder, making the sea boil, and the commotion often extends to a distance of 16 miles. While travelling along the W. coast of Greenland, Dr. H. Rinks counted 23 icy platforms descending from the table-land into the fiords, and forcing the ice in many cases far into the sea, especially between 67½° and 73° N. lat. Now the thickness of the plain of ice cannot be less than the least diameter of the icebergs, which are its fragments; and as many icebergs are 100 or 150 feet high, 4000 feet in circumference, and since two-thirds of their mass is under water, Dr. Rinks computes that, between the preceding parallels, the plain of ice covering Greenland must be 1000 feet thick. These icy platforms, and probably many others more to the N., are the chief sources of icebergs in Baffin Bay and Davis Strait, which, carried by currents, are stranded on the Arctic coast, or are drawn into lower latitudes. The ice is very transparent and compact in the Arctic regions; its prevailing tints are blue, green, and orange, which, contrasted with the dazzling whiteness of the snow and the gloomy hue of the rocks, produce a striking effect.

A great fiord in the 68th parallel of latitude is supposed to extend completely across the table-land, dividing the country into South and North Greenland, which last extends to an unknown distance towards the pole on the E. coast, which is altogether inaccessible from the frozen sea and iron-bound shore, so that, excepting a very small portion of the coast, it is an unexplored region. On the W. side, however, Dr. Kane reached its northern termination in 82° 22′ N. lat., and 65° 35′ W. long., where it was washed by the Polar Ocean; so that it is unconnected with the polar lands to the W., and consequently a great island.

In some sheltered spots in South Greenland, especially along the borders of the fiords, there are meadows where the service-tree bears fruit, beech and willow grow by the streams, but not taller than a man; still farther N. the willow and juniper scarcely rise above the surface; yet this country has a flora peculiar to itself. S. of the island of Disco, on the W. coast, Danish colonies and missionaries have formed settlements on some of the islands and at the mouths of fiords; the Esquimaux inhabit the coasts even to the N. extremity of Baffin Bay.

§ 3. The pelagic islands in the Arctic Ocean are highly volcanic, with the exception of Spitzbergen. In the island of Spitzbergen the mountains spring sharp and majestic from the margin of the sea in dark gloomy masses, mixed with pure snow and enormous glaciers, presenting a sublime spectacle. Seven valleys filled by glaciers ending at the sea form a remarkable object on the E. coast. One of the largest masses of ice seen by Captain Scoresby on the island was N. of Horn Sound: it extended 11 miles along the shore, with a sea-face in one part more than 2000 feet high, from which he saw a huge fragment hurled into the sea, which it lashed into vapour, as it broke into a thousand pieces. The sun is not seen for several months in the year, and the cold is consequently intense.

Since 1858 the Swedes have sent four scientific expeditions to Spitzbergen, and have greatly extended our knowledge of the geography and productions of this group of islands. Tertiary deposits have been found, with fossil plants, proving that the islands at that epoch possessed a temperate climate.

Although the direct rays of the sun are powerful in sheltered spots within the Arctic Circle, the thermometer does not rise above 45° of Fahrenheit. July is the only month in which snow does not fall, and in the end of August the sea at night is covered with a thin coating of ice, and a summer often passes without one day that can be called warm. The snow-blink, the aurora borealis, the stars, and the moon, which, when in her northern declination, appears above the horizon for 10 or 12 days without intermission, furnish the principal light the inhabitants enjoy during their long and dreary winter.

§ 4. Iceland is 200 miles E. from Greenland, and lies S. of the Arctic Circle, which its most northern part touches. Though a fifth part larger than Ireland, not more than 4000 square miles are habitable, all besides being a chaos of volcanoes and ice.

The peculiar feature of Iceland lies in a trachytic region, which seems to rest on an ocean of fire. It consists of two vast parallel table-lands covered with ice-clad mountains, stretching from N.E. to S.W. through the very centre of the island, separated by a longitudinal valley nearly 100 miles wide, which reaches from sea to sea. These mountains assume rounded forms, with long level summits or domes with sloping declivities, as in the trachytic mountains of the Andes and elsewhere; but such huge masses of tufa and conglomerate project from their sides in perpendicular or overhanging precipices, separated by deep ravines, that the regularity of their structure can only be perceived from a distance; they conceal under a cold and tranquil coating of ice the fiery germs of terrific convulsions, sometimes bursting into dreadful activity, sometimes quiescent for ages. The most extensive of the two parallel ranges of Jökuls or Ice Mountains runs along the eastern side of the valley, and contains Oraëfa Jökul, 6241 feet high, the highest point in Iceland, seen like a white cloud from a great distance at sea: the western high land passes through the centre of the island.

Plains of ice cover many thousand square miles in Iceland, and glaciers, descending from the mountains, push far into the lowlands. This tendency of the ice to encroach has very materially diminished the quantity of habitable ground, and the progress of the ice plains is facilitated by the influence of the ocean of subterranean fire, which heats the superincumbent ground, and loosens the ice.

The longitudinal space between the mountainous table-lands is a low valley 100 miles wide, extending from sea to sea, where a substratum of trachyte is covered with lava, sand, and ashes, studded with low volcanic cones. It is a tremendous desert, never approached without dread even by the natives—a scene of perpetual conflict between the antagonistic powers of fire and frost, without a drop of water or a blade of grass; no living creature is to be seen—not a bird, nor even an insect. The surface is a confused mass of streams of lava rent by crevices: rocks piled on rocks, and occasional glaciers complete the scene of desolation. As herds of reindeer are seen browsing on the lichens that grow plentifully at its edges, it is presumed that some unknown parts may be less barren. The extremities of the valley are more especially the seats of perpetual volcanic activity. At the southern end, which opens to the sea in a wide plain, there are many volcanoes, of which Hecla is most known, from its insulated position, its vicinity to the coast, and its terrific eruptions. Between the years 1004 and 1766, 23 violent eruptions have taken place, one of which continued six years, spreading devastation over a country once the abode of a thriving colony, now covered with lava, scoria, and ashes: in the year 1846 it was in full activity. The eruption of the Skaptar Jökul, which broke out on the 8th of May, 1783, and continued till August, is one of the most dreadful recorded. The volcanic fire must have been in fearful commotion under Europe, for a tremendous earthquake ruined a wide extent of Calabria that year, and a submarine volcano had been burning fiercely for many weeks in the ocean, 30 miles from the S.W. cape of Iceland. Its fires suddenly ceased, the island was shaken by earthquakes, when, at the distance of 150 miles, they burst forth with almost unexampled fury in Skaptar. The sun was hid many months by dense masses of vapour, which extended to England and Holland, and clouds of ashes were carried many hundreds of miles to sea. The quantity of matter thrown out in this eruption was computed at 50 or 60 thousand millions of cubic yards. The lava flowed in a stream in some places from 20 to 30 miles broad, and of enormous thickness, which filled the beds of rivers, poured into the sea nearly 50 miles from the place of its eruption, and destroyed the fishing on the coast. Some rivers were heated to ebullition, others dried up; the condensed vapour fell in snow and torrents of rain; the country was laid waste; famine and disease ensued; and in the course of the two succeeding years 1300 people and 150,000 sheep and horses perished. The scene of horror was closed by a dreadful earthquake. Previous to the explosion an ominous mildness of temperature indicated the approach of the volcanic fire towards the surface of the earth; similar warnings had been observed before in the eruptions of Hecla.

A semicircle of volcanic mountains on the eastern side of the lake Myvatn is the focus of the igneous phenomena at the northern end of the great central valley. Leirhnukr and Krabla, on the N.E. of the lake, have been equally formidable. After years of quiescence they suddenly burst into violent eruption, and poured such a quantity of lava into the lake Myvatn, which is 20 miles in circumference, that the water boiled many days. There are other volcanoes in this district no less formidable. Various caldrons of boiling mineral pitch, the shattered craters of ancient volcanoes, occur at the base of this semicircle of mountains, and also on the flanks of Mount Krabla: these caldrons throw up jets of the dark matter, enveloped in clouds of steam, at regular intervals, with loud explosion. That which issues from the crater of Krabla must, by Mr. Henderson's description, be one of the most terrific objects in nature.

The eruptive boiling springs of Iceland are perhaps the most extraordinary phenomena in this singular country. All the great aqueous eruptions occur in the trachytic formation; they are characterised by their high temperature, by holding silicious matter in solution, which they deposit in the form of silicious sinter, and by the discharge of sulphuretted hydrogen gas. Numerous instances of spouting springs occur at the extremities of the great central valley, especially at its southern end, where more than 50 have been counted in the space of a few acres—some constant, others periodical—some merely agitated or stagnant. The Great Geyser and Strokr, 35 miles N.W. from Hecla, are the most magnificent; at irregular intervals they project large columns of boiling water 100 feet high, enveloped in clouds of steam, with a tremendous noise. The tube of the Great Geyser whence the jet issues is about 10 feet in diameter and 75 feet deep; it opens into the centre of a basin four feet deep and between 46 and 50 feet in diameter; as soon as the basin is filled with boiling water that rises through the tube, explosions are heard, the ground trembles, the water is thrown to the height of 100 or 150 feet, followed by large volumes of steam. No further explosion takes place till the empty basin and tube are again replenished.

MM. Descloiseaux and Bunsen, who visited Iceland in 1846, found the temperature of the Great Geyser, at the depth of 72 feet, before a great eruption, to be 260½° of Fahrenheit, and after the eruption 251½°; an interval of 28 hours passed without any eruption. The Strokr (from stroka, to agitate), 140 yards from the Great Geyser, is a circular well, a little more than 44 feet deep, with an orifice of 8 feet, which diminishes to little more than 10 inches at a depth of 27 feet. The surface of the water is in constant ebullition, while at the bottom the temperature exceeds that of boiling water by about 24°. By the experiments of M. Donny of Ghent, water long boiled becomes more and more free from air, by which the cohesion of the particles is so much increased that, when it is exposed to a heat sufficient to overcome the force of cohesion, the production of steam is so instantaneous and so considerable as to cause explosion. To this cause he ascribes the eruptions of the Geysers, which are in constant ebullition for many hours, and become so purified from air, that the strong heat at the bottom at last overcomes the cohesion of the particles, and an explosion takes place. The boiling spring of Tunquhaer, in the valley of Reikholt, is remarkable from having two jets, which play alternately for about four minutes each. Some springs emit gas only, or gas with a small quantity of water. Such fountains are not confined to the land or fields of ice; they occur also in the sea, and many issue from the crevices in the lava-bed of Lake Myvatn, and rise in jets above the surface of the water.

A region of the same character with the mountains of the Icelandic desert extends due W. from it to the extremity of the long narrow promontory of the Snaefell Syssel, ending in the snow-clad cone of the Snaefell Jökul, 4577 feet high, one of the most conspicuous mountains in Iceland.

With the exception of the purely volcanic districts described, trap-rocks cover a great part of Iceland, wkich have been formed by streams of lava at very ancient epochs, occasionally 4000 feet deep.

The dismal coasts are torn, except on the S., by fiords, penetrating many miles into the interior, and spreading into endless branches. In these fissures the sea is still, dark, and deep, between walls of rock 1000 feet high. The fiords, however, do not here, as in Greenland, terminate in glaciers, but are prolonged in narrow valleys, through which streams and rivers run to the sea. In these valleys the inhabitants have their abode, or in meadows which have a transient verdure along some of the fiords, where the sea is so deep that ships find safe anchorage.

In the valleys on the northern coast, near as they approach to the Arctic Circle, the soil is wonderfully good, and there is more vegetation than in any other part of Iceland, with the exception of the eastern shore, which is the most favoured portion of this desolate land. Rivers abounding in fish are much more frequent there than elsewhere; willows and juniper adorn the valleys, and birch-trees, 20 feet high, grow in the vale of Lagerflest, the only place which produces them large enough for house-building, and the verdure is fine on the banks of those streams which are heated by volcanic fires.

The climate of Iceland is much less rigorous than that of Greenland, and it would be still milder were the air not chilled by the immense fields of ice from the Polar Sea which beset its shores.

The inhabitants are supplied with fuel by the Gulf Stream, which brings drift-wood in great quantities from Mexico, the Carolinas, Virginia, the river St. Lawrence; and some even from the Pacific Ocean is supposed to be drifted by currents round by the northern shores of Siberia. The mean temperature in the S. of the island is about 39° of Fahrenheit, that of the central districts 36°, and in the N. it is rarely above the freezing-point. The cold is most intense when the sky is clear, but that is a rare occurrence, as the moist wind from the sea covers mountain and valley with thick fog. Hurricanes are frequent and violent; and although thunder is seldom heard in high latitudes, Iceland is an exception, for tremendous thunderstorms are not uncommon there — a circumstance attributed to the volcanic nature of that island, as lightning accompanies volcanic eruptions everywhere. At the northern end of the island the sun is always above the horizon in the middle of summer, and under it in mid-winter, yet there is no absolute darkness.

The island of Jan Mayen lies between Iceland and Spitzbergen; it is the most northern volcanic country known. Its principal feature is the volcano of Beerenberg, 6870 feet high, whose lofty snow-capped cone, apparently inaccessible, has been seen to emit fire and smoke. It is flanked by enormous glaciers, like frozen cataracts, which occupy three hollows in an almost perpendicular cliff, descending from the base of the mountain to the sea.

The group of islands of New Siberia, which lie N. of the province of Yakutsk, and in about 78° of N. lat., have so rude a climate that they have no permanent inhabitants; they are remarkable for the quantity of fossil bones they contain: the elephants' tusks found there have for years been an article of commerce.

§ 5. The S. polar lands are equally volcanic, and as deeply ice-bound, as those in the N. Victoria Land, which from its extent seems to form part of a continent, was discovered by Sir James Ross, who commanded the expedition sent by the British government in 1839 to ascertain the position of the S. magnetic pole. This extensive tract lies S. of New Zealand; Cape North, its most northern point, is situate in 70° 31′ S. lat. and 165° 28′ E. long. To the W. of that cape the northern coast of this land terminates in perpendicular ice-cliffs, from 200 to 500 feet high, stretching as far as the eye can reach, with a chain of grounded icebergs extending for miles from their base, all of tabular form, and varying in size from one to nine or ten miles in circumference. A lofty range of peaked mountains rises in the interior at Cape North, covered with unbroken snow, only relieved from uniform whiteness by shadows produced by the undulations of the surface. The indentations of the coast are filled with ice many hundreds of feet thick, which makes it impossible to land. To the E. of Cape North the coast trends first to S.E. by E. and then in a southerly direction to 78½° of S. lat., at which point it suddenly bends to the E., and extends in one continuous vertical ice-cliff to an unknown distance in that direction. The first view of Victoria Land is described as most magnificent. "On the 11th of January, 1841, in about latitude 71° S. and longitude 171° E., the Antarctic continent was first seen, the general outline of which at once indicated its volcanic character, rising steeply from the ocean in a stupendous mountain-range, peak above peak enveloped in perpetual snow, and clustered together in countless groups, resembling a vast mass of crystallisation, which, as the sun's rays were reflected on it, exhibited a scene of such unequalled magnificence and splendour as would baffle all power of language to portray, or give the faintest conception of. One very remarkable peak, in shape like a huge crystal of quartz, rose to the height of 7867 feet, another to 9096, and a third to 8444 feet above the level of the sea. From these peaks ridges descended to the coast, terminating abruptly in bold capes and promontories, whose steep escarpments, affording shelter to neither ice nor snow, alone showed the jet black lava or basalt which reposed beneath the mantle of eternal frost." . . . . "On the 28th, in lat. 77° 31′ and long. 167° 1′, the burning volcano, Mount Erebus, was discovered, enveloped in ice and snow from its base to its summit, from which a dense column of black smoke towered high above the other numerous lofty cones and crateriferous peaks with which this extraordinary land is studded from the 72nd to the 78th degree of latitude. Its height above the sea is 12,367 feet, and Mount Terror, an extinct crater near to it, which has doubtless once given vent to fires beneath, attains an altitude little inferior, being 10,884 feet in height, and ending in a cape, from which a vast barrier of ice extended in an easterly direction, checking all further progress S. This continuous perpendicular wall of ice, varying in height from 200 to 100 feet, its summit presenting an almost unvarying level outline, we traced for 300 miles, when the pack-ice obstructed all farther progress."[1]

The vertical cliff in question forms a completely solid mass of ice about 1000 feet thick, the greater part of which is below the surface of the sea; there is not the smallest appearance of a fissure throughout its whole extent, and the intensely blue sky beyond indicated plainly the great distance to which the ice-plains reach southward. Gigantic icicles hang from every projecting point of the icy cliff, showing that it sometimes thaws in these latitudes, although in the month of February, which corresponds with August in England, Fahrenheit's thermometer did not rise above 14° at noon. In the North Polar Ocean, on the contrary, streams of water flow from every iceberg during the summer. The whole of this country is beyond the pale of vegetation; no moss, not even a lichen, covers the barren soil where everlasting winter reigns. Parry Mountains, a lofty range, stretching S. from Mount Terror to the 79th parallel, is the most southern land yet discovered. The South Magnetic Pole, one of the objects of the expedition, would be situated in Victoria Land, in 75° 5′ S. lat., and 154° 8′ E. long., according to Sir James C. Ross's observations.

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[1] Remarks on the Antarctic Continent and Southern Islands, by Robert MacCormick, Esq., Surgeon of H.M.S. Erebus.

Various tracts of land have been discovered near the Antarctic Circle, and within it, though none in so high a latitude as Victoria Land. Whether they form part of one large continent remains to be ascertained. Scientific expeditions sent by the Russian, French, and American governments have increased our knowledge of these remote regions, and the spirited adventures of British merchants and captains of whalers have contributed quite as much.[1] The land within the Antarctic Circle is generally volcanic—at least the coast-line, which is all that is yet known, and that, being covered with snow and ice, is destitute of vegetation.

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[1] Captain Cook discovered Sandwich Land in 1772-5.—Captain Smith, of the brig 'William,' discovered New South Shetland in 1819.—Captain Billingshausen discovered Peter Island, and the coast of Alexander the First.—Captain Weddel discovered the Southern Orcades.—Captain Bisco discovered Enderby Land and Graham Land in 1832; Admiral Dumont d'Urville, la Terre d'Adelie in 1841; and Sir James Ross, Victoria Land in the same year.

CHAPTER XVII.

MINERALS.

§ 1. Nature and character of mineral veins; magnetism of the earth. § 2. Metalliferous deposits. § 3. Mines; their drainage and ventilation; depth of mines. § 4. Diffusion of metals; gold; silver; lead; quicksilver; copper; tin-mines of Cornwall; iron. § 5. Coal-mines; disposition of the coal-strata; British coal-fields; enormous carboniferous strata of America; tropical coal-fields uninvestigated. § 6. Arsenic and other metals; salt; sulphur. § 7. Diffusion of the gems.

§ 1. THE tumultuous and sudden action of the volcano and the earthquake on the great masses of the earth is in strong contrast with the calm, silent operations on the minute atoms of matter by which Nature seems to have filled the fissures in the rocks with her precious gifts of metals and minerals, sought for by man from the earliest ages to the present day. Tubal-cain was "the instructor of every artificer in brass and iron." Gold was among the first luxuries; and even in our own country, from time immemorial, strangers came from afar to carry off the produce of the Cornish mines.[1]

The ancients scarcely were acquainted with a third of the metals now known, and the metallic bases of the alkalis only date from the time of Sir Humphry Davy, having formed a remarkable part of his brilliant discoveries.[2]

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[1] The author owes her information on British mines to two publications on the Mining District of the North of England, by J. Sopwith, Esq., Civil Engineer, and Mr. Leithart, Mine Agent. On the Cornish Mines she has derived her information from the writings of John Taylor, Esq., and Sir Charles Lemon, Bart.; from a store of valuable materials contained in the 'Progress of the Nation,' by G. R. Porter, Esq.; from the Mineral Statistics of the United Kingdom, by Robert Hunt, F.R.S., published in the Memoirs of the Geological Survey of Great Britain; from the Statistical Journal; and on the general distribution of minerals over the globe, from the 'Penny Cyclopædia,' and various other sources.

[2] LIST OF ELEMENTARY BODIES.

Aluminium—(Wöhler, 1828).
Antimony.
Arsenic—(Brandt, 1733).
Barium—(Davy, 1807).
Beryllium or Glucinum—(Wöhler, 1828).

Bismuth.

Minerals are deposited in veins or fissures of rocks, in masses, in beds, and sometimes rolled fragments imbedded in gravel and sand, the detritus of water. Most of the metals are found in veins; a few, as gold and tin, iron and copper ores, are disseminated through the rocks, though rarely. Veins are cracks or fissures in rocks, seldom in a straight line, yet they maintain a general direction, though in a zigzag form, striking downwards at a very high angle,

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LIST OF ELEMENTARY BODIES—(*continued*).

Bismuth.
Boron—(Gay-Lussac, Thénard, Davy, 1808).
Bromine—(Balard, 1826).
Cadmium—(Stromeyer, 1818).
Cæsium—(Bunsen and Kirchhoff, 1860).
Calcium—(Davy, 1807).
Carbon.
Cerium—(Klaproth, 1803).
Chlorine—(Scheele, 1774).
Chromium—(Vauquelin, 1797).
Cobalt—(Brandt, 1733).
Copper.
Didymium—(Mosander, 1841).
Erbium—(Bahr and Bunsen).
Fluorine—(never isolated).
Gold.
Hydrogen.
Indium—(Reich and Richter, about 1863).
Iodine—(Courtois, 1811).
Iridium—(Descotils: Tennant, 1803).
Iron.
Lanthanum—(Mosander, 1839).
Lead.
Lithium—(Arfwedson, 1818).
Magnesium—(Bussy, 1829).
Manganese—(Galm: Scheele, 1774).
Mercury.
Molybdenum—(Hjelm, 1782).
Nickel—(Cronstedt, 1751).
Niobium—(Hatchett, 1801).
Nitrogen—(Rutherford).
Osmium—(S. Tennant, 1803).
Oxygen—(Priestley, Scheele, 1774).
Palladium—(Wollaston, 1803).
Phosphorus—(Brandt, 1769).
Platinum—(Wood, 1741).
Potassium—(Davy, 1807).
Rhodium—(Wollaston, 1804).
Rubidium—(Bunsen and Kirchhoff, 1861).
Ruthenium—(Claus, 1846).
Selenium—(Berzelius, 1817).
Silicium—(Berzelius, 1810).
Silver.
Sodium—(Davy, 1807).
Strontium—(Davy, 1807).
Sulphur.
Tantalum—(Ekeberg, 1803).
Tellurium—(Müller, 1782).
? Terbium—(The existence of this supposed metal is not proven).
Thallium—(Crookes: Lamy, 1862).
Thorinum—(Berzelius, 1828).
Tin.
Titanium—(Gregor, 1791).
Tungsten—(d'Elhujar, 1783).
Uranium—(Klaproth, 1789).
Vanadium—(Del Rio, 1801).
Yttrium—(Berzelius and others have described the impure metal. It has not been obtained pure.)
Zinc.
Zirconium—(Klaproth, 1787).

Spectroscopic indications of two or three new elements associated with zirconium have recently been obtained by Sorby and Church. It would, however, be premature to include "jargonium" and its congeners among known elements.

The 14 elements indicated by the names printed in italics are *usually* regarded as non-metallic. The division of elements into metals and non-metals is, however, quite an arbitrary one. *Hydrogen* is related to the metals lithium, sodium, potassium, and silver; *arsenic* is related to nitrogen; in fine, there is no chemical line of separation between the elements usually considered to be non-metallic and those usually regarded as metals.

seldom deviating from the perpendicular by so much as 45 degrees, and extending to variable depths. When cutting through stratified rocks, they are for the most part accompanied by a depression of the beds on one side of their course, and by an elevation on the other; the throw, or perpendicular distance between the corresponding strata on the opposite sides of a vein, varies from a few inches to thirty, forty, even a hundred fathoms. The beginning or end of a vein is scarcely ever known; but, when explored, they are found to begin abruptly, and, after continuing undivided to a greater or less distance, they branch into small veins or strings.

In the downward zigzag course, the bending of the strata upwards on one side and downwards on the other, and the chemical changes almost always observed on the adjacent rocks, veins bear a strong analogy to the course and effects of a very powerful electrical discharge.

Veins have been filled with substances foreign to them, which have probably been disseminated by sublimation from the interior of the earth. Nothing can be more certain than that the minute particles of matter are constantly in motion from the action of heat, mutual attraction, and electricity. Prismatic crystals of salts of zinc are changed in a few seconds into crystals of a totally different form by the heat of the sun: casts of shells are found in rocks, from which the animal matter has been removed, and its place supplied by mineral matter; and the excavations made in rocks diminish sensibly in size in a short time if the rock be soft, and in a longer time when it is hard — circumstances that show an intestine motion of the particles, not only in their relative positions, but in space, which there is every reason to believe is owing to electricity —a power which, if not the sole agent, must at least have co-operated essentially in the formation and filling of mineral veins.[1]

The magnetism of the earth is presumed to be owing to electrical currents circulating through its mass in a direction at right angles to the magnetic meridians. Mr. Fox has shown, from observations in the Cornish mines, that such currents do flow through all metallic veins. Now, as the different substances of which the earth is composed are in different states of electro-magnetism, and are often interrupted by non-conducting rocks, the electric currents, being stopped in their course, act chemically on all the liquids and substances they meet with. Hence Mr. Fox has come to the conclusion that not only the nature of the deposits must have been determined by their relative electrical conditions, but that the direction of the metallic veins themselves must have been influenced by the direction of the magnetic meridians; and, in fact, almost all the metallic deposits in the world are in parallel veins or fissures trending from E. to W., or from N.E. to S.W. Veins at right angles to these are generally non-metalliferous, and, if they do contain metallic ores, they are of a different kind. In some few cases both contain the same ore, but in very different quantities, and both veins are richer near the point of crossing than elsewhere.

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[1] This subject is ably discussed by Mr. Leithart in his work, already mentioned, on the formation and filling of metallic veins. Mr. Leithart is an instance of the intelligence that prevails among miners, notwithstanding the scanty opportunities of acquiring that knowledge which they are generally so eager to obtain. He was a working miner, whose only education was at a Sunday-school. There are and have been many eminent engineers in England, employed in the construction of railways, canals, bridges, and other important works, who began their career as working miners.

Sir Henry de la Beche conceived that the continued expansion and elevation of an intensely heated mass from below would occasion numerous vertical fissures through the superincumbent strata, within which some mineral matters may have been drawn up by sublimation, and others deposited in them when held in solution by ascending and descending streams of water; even on this hypothesis the direction of the rents and the deposition of the minerals would be influenced by the electrical currents. But if veins were filled from below, the richest veins would be lowest, which is not the case in Cornwall, Mexico, or Peru, where they are generally richer near the surface than at great depths: this is particularly the case in the mines of the precious metals in America, where the greatest quantities of ore have been found near the surface—a fact that may be explained by supposing the mineral substances brought by sublimation from the interior of the earth, and deposited where the temperature was lowest at or near the surface in the rocks among which they are situated. The primum mobile of the whole probably lies far beyond our globe: we must look to the sun's heat, if not as the sole cause of electrical currents, at least as combined with the earth's rotation in their evolution.[1]

When veins cross one another, the veins traversed are presumed to be of prior formation to those traversing, because the latter are dislocated and often heaved out of their course at the point of intersection; and such is the case with the metalliferous veins, which are therefore the most recent. Veins are rarely filled in every part with ore; they contain sparry and stony matter, called the matrix, with here and there irregular masses of the metallic ores, often of great size and value. Solitary veins are generally unproductive, and veins are richer when near one another. The prevalence and richness of mineral veins are intimately connected with the proximity or junction of dissimilar rocks, where the electro-molecular and electro-chemical actions are most energetic. Granite, porphyry, and the plutonic rocks are often eminently metalliferous; but mineral deposits are also abundant in rocks of sedimentary origin, especially in and near situations where these two classes of rocks are in contact with one another, or where the metamorphic structure has been induced upon the sedimentary. This is remarkably the case in Cornwall, the north of England, in the Ural, and most of the great mining districts on the continent of Europe.

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[1] Rotation alone produces electrical currents in the earth.—'Connexion of the Physical Sciences,' page 364, 7th edition.

§ 2. Metalliferous deposits are peculiar to particular rocks; tin is most plentiful in granite and the rocks lying immediately above it; gold in the Palæozoic rocks in the vicinity of porphyritic eruptions; copper is deposited in various slate formations, and in the sandstones of the trias, in certain porphyritic rocks, and in serpentine; lead is particularly abundant in the carboniferous limestone system, and is rare where there is iron and copper; iron abounds in the coal and oolitic strata, and in a state of oxid and crystallized carbonate in the plutonic and metamorphic rocks; and silver is found in almost all of these formations; its ores being frequently combined with those of other metals, especially of lead and copper. There is such a connexion between the contents of a vein and the nature of the rock in which the fissure is that, when in the oldest rocks the same vein intersects clay-slate and granite, the contents of the parts enclosed in one rock differ very much from what is found in the other. It is believed that in the strata lying above the coal-measures none of the more precious metals have been found in England in such plenty as to defray the expense of raising them, although such a rule does not extend to the continent of Europe or to South America, where copper and silver ores abound in the red sandstone of the triassic series. In Great Britain no metal, except iron, is raised in any stratum newer than the magnesian limestone. Metals exist chiefly in the primary and early secondary strata, especially near the junction of granite and porphyry with slates; and it is a fact that rich veins of lead, copper, tin, &c., abound only in and near the districts which have been greatly shaken by subterraneous movements. In other countries, as Auvergne and the Pyrenees, the presence of igneous rocks may have caused mineral veins to appear in more recent strata than those which contain them in Great Britain.

§ 3. When a mine is opened, a shaft like a well is generally sunk perpendicularly from the surface of the ground, and from it horizontal galleries are dug at different levels according to the direction of the metallic veins, and gunpowder is used to blast the rocks when too hard for the pickaxe. When mines extend very far in a horizontal direction, it becomes necessary to sink more shafts, for ventilation as well as for facility in raising the ore. Such is the perfection of underground surveying in England, that the work can be carried on at the same time from above and below so exactly as to meet; and in order to accelerate the operation, the shaft is worked simultaneously from the different galleries or levels of the mine. In this manner a perpendicular shaft was sunk 204 fathoms deep, in the Consolidated mines, in Cornwall; it was finished in 12 months, having been worked in 15 different points at once. In that mine, some years ago, there were 95 shafts, besides other perpendicular communications underground from level to level: the depth of the whole of these shafts added together amounted to about 25 miles; the galleries and levels extending horizontally about 43 miles; and 2500 persons were employed in it; yet this is but one of many mines now in operation in the mining district of Cornwall alone.[1]

The infiltration of the rain and surface-water, together with subterranean springs, would soon inundate a mine and put a stop to the work, were not adequate means employed to remove it. The steam-engine is often the only way of accomplishing what in many cases would otherwise be impossible, and the produce of mines has been in proportion to the successive improvements in that machine.

Mines in high ground are sometimes drained to a certain depth by an adit or gallery dug from the bottom of a shaft in a sloping direction to a neighbouring valley. One of these adits extends through the large mining district of Gwennap, in Cornwall; it begins in a valley near the sea, and very little above its level, and communicates with all the neighbouring mines, which it drains to that depth, and with all its ramifications is 30 miles long. Nent Force Level, in the north of England, forms a similar drain to the mines in Alston Moor; it is a stupendous aqueduct, nine feet broad, and in some places from 16 to 20 feet high; it passes for more than three miles under the course of the river Nent to Nentsbury engine-shaft, and is navigated underground by long narrow boats. Daylight at its mouth is seen like a star at the distance of a mile in the interior. Most of the adits admit of the passage of men and horses, with rails at the sides for waggons.

The access to deep mines, as in Cornwall, is usually by a series of perpendicular or slightly inclined ladders, sometimes uninterrupted, but generally broken at intervals by resting-places. It is computed that one-third of a miner's physical strength is exhausted in ascending and descending a deep mine. The man-engine, which is a series of platforms fixed on a perpendicular rod worked by the steam-engine is now used in a few of the deepest mines.

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[1] J. Taylor, Esq., on Cornish Mines.

The greatest depth to which man has excavated is nothing when compared with the radius of the earth. The Eselschacht mine at Kuttenberg, in Bohemia, now inaccessible, which is 3778 feet below the surface, is deeper than any other mine. Its depth is only 150 feet less than the height of Vesuvius, and it is eight times greater than the height of the pyramid of Cheops, or the cathedral of Strasburg. The Monkwearmouth coal-mine, near Sunderland, descends to 1500 feet below the level of the sea, so that the barometer stands there at 31·70, which is higher than anywhere on the earth's surface.[1] The salt works of Neu-Salzwerk, in Prussia, are 2231 feet deep, and 1993 feet below the level of the sea. Mines on high ground may be very deep without extending to the sea-level: that of Valenciana, near Guanaxuato, in Mexico, is 1686 feet deep, yet its bottom is 5960 feet above the surface of the sea; and the mines in the higher Andes must be much more. For the same reason the rich mine of Joachimsthal, in Bohemia, 2120 feet deep, has not yet reached that level. The fire-springs at Tseu-lieu-tsing, in China, are 3197 feet deep, but their relative depth is unknown.[2] How insignificant are all the works of man compared with nature!

§ 4. The metals are very profusely diffused over the earth. Few countries of any extent do not contain some of them. A small number occur pure, but in general they exist in the form of ores, in which the metal is chemically combined with other substances and they are often so mixed with earthy matter and rock that it is necessary to reduce them to a coarse powder in order to separate the metallic portion, which is rarely more than a third or fourth part of the mass brought above ground.

Gold is chiefly found in the Palæozoic strata where traversed by plutonic rocks, disseminated in veins and small threads or grains in the matrix itself; the upper part of the rocks or veins containing the metal is in general the richest, decreasing in quantity with the depth. Most of the surface gold has already been removed by natural causes; and although gold is found in almost every country, it is in such minute quantities that it is often not worth the expense of working. It is almost always in a native state, and in the form of crystals, grains, or masses called nuggets. Sometimes it is combined with silver; but it is chiefly in the alluvial deposits, resulting from the destruction and disintegration of the originally auriferous rocks, that this precious metal is now procured. It is exhausted in several parts of Europe where it was formerly found. The united produce of the mines in Transylvania, Hungary, the north-western districts of Austria, and the bed of the Danube, is nearly 60,000 ounces annually. Gold is found in small quantities in Spain, in Wales, in Scotland at Leadhills, and in Sutherlandshire, and in the Wicklow mountains in Ireland.

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[1] Supposing the barometer to be 30 inches on the level of the sea.

[2] Note to the English translation of Kosmos, by General Sabine, on the depths below the surface of the earth attained by man.

Gold abounds in Asia, especially in Siberia. The alluvial deposits at the foot of the Ural mountains are very rich. In 1826 a piece of pure gold weighing 23 pounds was found there, along with others weighing three or four pounds each, accompanied by bones of elephants. The alluvium there is ferruginous: and more to the E., as already mentioned, a rich auriferous region as large as France has lately been discovered, resting on rocks which contain it. In 1834 the treasures in that part of the Altaï chain called the Gold Mountains were discovered, forming a mountain-knot nearly as large as England, from which a great quantity of gold has been extracted. Gold is found in Tibet, in the Chinese province of Yunnan, in the mountains of the Indo-Chinese peninsula, in Japan, and Borneo. In the latter island it occurs near the surface in several places.

Africa has long furnished a considerable supply to Europe. That part of the Kong mountains W. of the meridian of Greenwich was one of the most auriferous regions in the world before the discoveries in California. The auriferous stratum lies from 20 to 25 feet below the surface, and increases in richness with the depth. The gold is found in particles and pieces in a reddish sand. Most of the streams from the table-land bring down gold, as well those that descend to the low ground to the N. as those that flow to the Atlantic, and the Indian Ocean, S. of Mozambique.

In South America the Western Cordillera is poor in metals except in New Grenada, where the most westerly of the three chains of the Andes is rich in gold and platinum—a metal found only there, in Brazil, and on the European side of the Ural mountains—and all in alluvial deposits. The largest piece of platinum that has been found weighed 21 ounces. Gold is found in alluvial deposits on the high plains of the Andes, on the low lands to the E. of them, and in almost all the rivers that flow on that side. The whole country between Jaen de Bracamoros and the river Guaviare is celebrated for its metallic riches. Almost all the Brazilian rivers bring down gold. The province of Minas Geraes is very rich in gold; and numerous mines, the chief of which is that of Morro Velho, are worked. The gold deposits of Minas Geraes are all the produce of primitive and metamorphic rocks, and there are three chief varieties of the gold-ore—viz. quartz-gold, Jacutinga (micaceous iron with free gold in lines and pot-holes), and pyritic formations (magnetic iron and arsenical pyrites, in which gold is minutely disseminated).

Central America, Mexico, California, and British Columbia are auriferous countries. The quantity of gold recently found near the surface in California exceeded that of all other countries until the discovery of the auriferous deposits in Australia, which in the year 1856 amounted to 12,633,138*l*. Victoria, New South Wales, and Queensland all yield large quantities of gold, and it is believed that this metal will ultimately be found in connection with all the mountain masses of the Australian continent. Gold-bearing quartz and alluvial deposits have also been found in Tasmania, at some distance from Launceston; and the diggings in both the North and Middle Islands of New Zealand have proved very valuable. In 1858, the gold-fields of British Columbia were first worked; and from that time to the end of 1863, gold to the value of 3,000,000*l*. was exported. The precious metal exists in all the tributaries of the Frazer, of which more than 60 are known. The most productive goldfield is that of Cariboo, lying between the Quesnelle Lake and the Upper Frazer. Gold has also been found to some extent in the S. of Vancouver Island, particularly in the valley of the Sooke River. A considerable quantity is found in Tenessee, the mountains of Georgia, and on 1000 square miles of North Carolina; in fact, it is found at intervals from Canada to Georgia, and it is now found in Nova Scotia.

A great deal of silver is raised in Europe. The mines of Hungary are the most productive, especially those in the mountains of Chemnitz. The metalliferous mountains of the Erzgebirge are very rich, and also the mines near Christiania, in Sweden. Silver is found in Saxony, Transylvania, and Austria. The lead-mines of England produced, in 1867, 215,400*l*. worth of this metal. In no part of the old continent is silver in greater abundance than in the Ural and Altaï mountains, especially in the district of Kolyvan. There are silver-mines in Armenia, Anatolia, Tibet, China, Cochin-China, and Japan.

The richness of the Andes in silver can hardly be conceived, but the mines are frequently on such high ground that the profits are diminished by the difficulty of carriage, the expense of living in a barren country, sometimes destitute of water, where the miners suffer from cold and snow, and especially the want of fuel. This is particularly the case at the silver-mines of Copiapo, in Chile, where the country is utterly barren, and not a drop of water is to be found in a circuit of nine miles. These mines were discovered by a poor man in 1832, who hit upon a mass of silver in rooting out a tree. They extend over 150 square leagues. 16 veins of silver were found in the first four days, and, before three weeks elapsed, 40 more, not reckoning smaller ramifications. The rolled pieces which lay on the surface produced a large quantity of pure silver. A single mass weighed 5000 pounds.[1] With Mexico, Chile is now the country most productive in silver.

In the mines of Copiapo the silver-veins are sometimes cut off by a dyke of limestone, but on the underside of the dyke it is found richer than ever, and crowned by a mass of pure silver, varying in weight from hundreds to even thousands of marcs. It often happens that vegetation is poor where mineral riches are great, especially in the countries where silver, lead, and coal are found. It is particularly the case in Atacama, where an immense and confused mass of sand and rocks of every colour and shade has the appearance of great cities destroyed by some terrible earthquake and then discoloured by fire. Yet even here a peculiar beauty sometimes prevails. Patches and streaks having every colour of the rainbow—from the green of the most luxuriant vegetation to the most brilliant yellow and red—point out the localities of immense deposits of copper and oxides of iron. These and the varied colours of quartz and porphyritic rocks, when heightened by the tints of a setting sun, gradually subsiding from the brighter colours into rose, then purple, and lastly a fading neutral tint, in a calm, pure, and transparent atmosphere, are surpassingly beautiful.[2]

In Peru there are silver-mines along the whole range of the Andes, from Caxamarca to the desert of Atacama. The most productive at present are those of Pasco, which were discovered by an Indian in 1630. They have been worked without interruption since the beginning of the 17th century. The soil under the town of Pasco is metalliferous, the ores probably forming a series of beds contemporaneous with the strata. The richness of these beds is not everywhere the same, but the nests of ore are numerous. The mines of Potosi, 16,150 feet above the sea-level, are celebrated for riches, but the owners have to contend with all the difficulties which such an elevated situation imposes. The small depth at which the silver lies in the high peaks of the Andes, and the greater abundance of it near the surface, is probably owing, as has been already stated in speaking of gold, to the greater deposition of the sublimed mineral from refrigeration near the surface. The ore in the mines at Chota is near the surface over an extent of half a square league, and the filaments of silver are sometimes even entwined with the roots of the grass. This mine is 13,300 feet above the level of the sea, and even in summer the thermometer is below the freezing-point in the night. In the district of Huantajaya, not far from the shores of the Pacific, there are mines where masses of pure silver were found, of which one weighed 800 pounds.[3] A large amount of silver is found in the Great Basin W. of the Rocky Mountains, and is worked in the territory of Nevada. In four years, silver to the value of eleven millions of pounds sterling was sent out from this district alone.

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[1] Dr. Pöppig's 'Travels in Chile and Peru.'

[2] Colonel Lloyd on the Mines of Copiapo.

[3] Dr. Pöppig.

According to Humboldt, the quantity of the precious metals brought to Europe between the discovery of America and the year 1803 was worth 1257 millions sterling; and the silver alone taken from the mines during that period would form a ball 89 feet in diameter. The disturbed state of the South American republics and the high price of quicksilver long interfered with the working of the mines, but quicksilver is now obtained in California.

Lead-ore is very often combined with silver, and is then called Argentiferous Galena. It is one of the principal productions of the British mines, especially in the northern mining district, which occupies 400 square miles at the junction of Northumberland, Cumberland, Westmoreland, Durham, and Yorkshire. It comprises Alston Moor, the mountain-ridge of Cross-fell, and the dales of Derwent, East and West Allendale, the Wear, and Tees. There are other extensive mining tracts separated from this by cultivated ground. The principal products of this rich district are lead and copper. The lead-mines lie chiefly in the upper dales of the Tyne, Wear, and Tees, and most of the ore contains a proportion of silver, though not always enough to indemnify the expense of refining or separating the silver. The deleterious vapours resulting from this process are conveyed in a tube along the surface of the ground for 14 miles; and instead of being, as formerly, a dead loss to the proprietor, they are condensed in their passage, and in one instance yielded metal to the annual value of 10,000*l.*[1] The total amount of lead produced from the mines of the United Kingdom alone, in 1867, was 93,432 tons, and of silver from their argentiferous galenas 805,394 ounces.

Lead-mines are worked in France, but not to any great amount; those of the S. of Spain furnish large quantities of this metal; also in Saxony, Bohemia, and Carinthia, where they are very rich. Lead is not very frequently found in Siberia, though it does occur in the Nertchinsk mining district, in the basin of the river Amur. It is also a production of Japan, of China, of the peninsula beyond the Ganges, of Lower Peru, Mexico, and California. But the most extensive lead-mines known in the world are in North America. They lie on both sides of the Upper Mississippi, and generally throughout the western section of the United States as well as in the States on the Atlantic. They are extensively worked, and were more so before the discovery of gold in California. The lead-mines in the valley of the Upper Mississippi are of truly wonderful extent, spreading over an area of 3,600 square miles, and the metal lies near the surface.

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[1] Constructed under the direction of Thomas Sopwith, Esq.

Quicksilver—a metal so important in separating silver from its ores, and in various arts and manufactures as well as in medicine—occurs either liquid in the native state or combined with sulphur in that of cinnabar. It is found in the mines of Idria and some other places in the Austrian empire, in the Palatinate on the left bank of the Rhine, in several parts of Tuscany, and in Spain. The richest quicksilver-mines of Europe, at the present day, are those of Almaden, where the quicksilver is found in the state of sulphuret chiefly disseminated in the Silurian strata. These mines were worked 700 years before the Christian era, and as many as 1200 tons of the metal are extracted annually. It occurs in China, Japan, and Ceylon, at San Onofrio in Mexico, and in Peru at Huancavelica, the mines of which, now almost abandoned, produced, up to the beginning of the present century, the enormous quantity of 54,000 tons of quicksilver. There is a mine of quicksilver, probably unrivalled in richness, 20 miles from San José, in the Clara valley of California, and three or four of cinnabar, the sulphuret of mercury, which were known to the Indians, who used the cinnabar to paint themselves. At one time there were more than two millions of pounds weight of ore lying at the mouth of the mine, from whence it is carried in skin sacks on the shoulders of men. It is supposed that this ore will produce 50 per cent. of pure quicksilver.

Copper is of such common occurrence that it would be vain to enumerate the localities where it is found. It is produced in Africa, in Persia, India, China, and Japan. The copper-mines in the United States of North America are probably the richest and most extensive in the world, especially those of Lake Superior, where masses 50 tons weight of pure copper have been found, and in the Cleff mine even of 60 or 80 tons, and a stratum of pure copper three feet thick has been cut through. Copper, as rich as any on Lake Superior, is found in Queensland and the interior of Australia. The Siberian mines are very productive both in ore and native copper. The choicest specimens of malachite, the most beautiful of its ores, come from Siberia. Almost every country in Europe yields copper. The mines in Sweden, Norway, and Germany are very productive; and it forms a principal part of our own mineral wealth. It is raised in all the principal mining districts in England and Wales. In Cornwall and Devon, where they are often associated with tin, its ores produced 10,233 tons of pure metal in 1867. The period at which the Cornish mines were first worked goes far beyond history, or even tradition: certain, however, it is that the Phœnicians came to Britain for tin. Probably copper was also worked very early in small quantities, for its exportation was forbidden in the time of Henry VIII. It was only in the beginning of the 18th century that the Cornish copper-mines were worked with success, by aid of the steam-engine and of an improved machine for draining them.[1]

In Cornwall and Devonshire, clay-slate rests upon granite, and is traversed by porphyritic dykes. The veins which contain copper or tin, or both, run E. and W., and penetrate both the granite and the clay-slate. The non-metalliferous veins run N. and S.; and if veins in that direction do contain any metal, it is never tin or copper, but lead, silver, cobalt, or antimony, which, with little exception, are believed to be always in the clay-slate. No miner in Cornwall has ever seen the end or bottom of a vein; their width varies from the thickness of a sheet of paper to 30 feet; the average is from one to three feet. It rarely happens that either tin or copper is found nearer the surface than 80 or 100 feet. If tin be first discovered, it sometimes disappears after sinking the mine 100 feet deeper, when copper is found, and in some instances tin is found 1000 feet deep without a trace of copper; but if copper is first discovered, it is very rarely succeeded by tin. Tin is found in rolled pieces, in alluvial beds of sand and gravel, and is then called stream-tin. With the exception of the Indian Archipelago, of all countries England is the most productive in tin-ores, which in 1867 gave 8700 tons of the pure metal. The most valuable tin-mines on the continent of Europe are those in Saxony; it also occurs in France, Bohemia, and Spain. One of the richest deposits of tin known is in the province of Tenasserim, on the E. side of the gulf of Martaban, in the Malayan peninsula. These deposits occur in several parts of that country; the richest is a layer eight or ten feet thick of sand and gravel, in which masses of oxide of tin are sometimes the size of a pigeon's egg. The best of all comes from the island of Banca, at the extremity of the peninsula of Malacca; a large portion of it is imported into Britain, and much goes to China. It is found in the alluvial tracts through every part of the island, rarely more than 25 feet below the surface. The whole tin-field extends at intervals over 17 degrees of latitude, and its produce is double that of Cornwall. Great deposits occur also in the Siberian mining district of Nertchinsk, near the desert of the Great Gobi, and near Oruro, in Bolivia; and stream-tin has been recently discovered in the auriferous deposits of South Australia.

There are comparatively few coal-mines worked within the tropics; they are mostly in the temperate zones, especially between the Arctic Circle and the Tropic of Cancer; and as iron, the most useful of metals, is chiefly found in the carboniferous strata, it follows the same distribution. In fact, the most productive iron-mines yet known are in the temperate zones. In the eastern mining district of Siberia, in the valley of the river Vilui, the ores are very rich, and very abundant in many parts of the Altaï and Ural. In the latter the mountain of Blagod, at 1534 feet above the sea, is one mass of magnetic iron-ore.[1] Coal and iron are worked in so many parts of Northern China, Japan, India, and Eastern Asia, that it would be tedious to enumerate them.

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[1] Sir Charles Lemon, Bart.

In Europe the richest mines of iron, like those of coal, lie chiefly N. of the Alps. Sweden, Norway, Russia, Germany, Styria, Belgium, and France, all contain it plentifully. In Britain many of the coal-fields contain subordinate beds of a rich argillaceous iron-ore, interstratified with coal, worked at the same time and in the same manner; besides, there is a substratum of limestone, which serves as a flux for melting the metal. The principal mines lie round Birmingham, in the Staffordshire coal-field, in the great coal-basin of South Wales about Pontypool and Merthyr Tydvil, and in Scotland about Glasgow. There are extensive iron-mines in Staffordshire, Shropshire, North and South Wales, Yorkshire, and Derbyshire. It would be impossible to state the number of mines which yield iron sufficient for our own enormous consumption and for exportation; but an idea may be formed of their extent when it is stated that in 1867 they furnished 10,021,058 tons of ore for the supply of 551½ blast-furnaces, which produced 4,761,023 tons of pig-iron, valued at 11,902,557*l.* sterling.

§ 5. These productive mines would have been of no avail had it not been for the abundance of fuel with which the greater part of them in the N. of England, Scotland, and Wales are associated—the great source of our national wealth, more precious than mines of gold. Most of the coal-mines would have been inaccessible but for the means which their produce affords of draining them at a small expense. A bushel of coals, which costs only a few pence, in the furnace of a steam-engine generates a power which in a few minutes will raise 20,000 gallons of water from a depth of 360 feet—an effect which could not be accomplished in a shorter time than a whole day by the continuous labour of 20 men working with the common pump. Yet this circumstance, so far from lessening the demand for human labour, has caused a greater number of men to be employed in the mines.

The coal-strata lie in basins, dipping from the sides towards the centre, which is often at a vast depth below the surface of the ground. The centre of the Liége coal-basin is 21,358 feet or 3½ geographical miles deep, which is easily estimated from the dip, or inclination, of the strata at the edges, and the extent of the basin. The coal lies in strata of small thickness and great extent. It varies in thickness from three to nine feet, though in some instances several layers come together, and then it is 20 and even 30 feet thick; but these layers are interrupted by frequent dislocations, which raise the coal-seam towards the surface. These fissures, which divide the coal-field into insulated masses, are filled with clay, so that an accumulation of water takes place, which must be pumped up.

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[1] M. Erman's 'Travels in Siberia.'

There are four great coal-fields in England: in 1867 the produce of these and of the Welsh mines amounted to 90 millions of tons. Should the produce continue at that rate, it has been computed that this coal-area will be exhausted in less than 1000 years unless means be discovered of working to a greater depth than 2000 feet, the obstacles being the creep or slow tendency of the roof and floor of the mine to meet from the increased pressure, and the want of more effectual ventilation to overcome the increase of the earth's temperature; probably both will be overcome: however, this estimate is independent of the Scotch and Irish coal.

The splendid discovery of Sir Humphry Davy, that flame does not pass through fine wire gauze, prevents the fatal explosion of inflammable air in the mines, by which thousands of lives have been lost. By means of a light enclosed in a wire-gauze lantern, a miner now works with safety surrounded by fire-damp. To the honour of the illustrious author of this discovery, be it observed that it was not, like that of gunpowder and others, the unforeseen result of chance by new combinations of matter, but the solution of a question based on scientific experiment and induction, which it required the genius of a philosophic mind like Davy's to arrive at. However, it is now doubted whether Davy's lamp is a protection on all occasions; yet it never fails to give warning of danger by the manner in which it burns.

The Scotch coal-field is a most important one, and occupies the great central low land of Scotland, lying between the southern high lands and the Highland mountains; the whole of that wide tract is occupied by it, besides which there are others of less extent. In 1867 the Scotch collieries produced 14,125,943 tons from 485 collieries. Coal has been found in 17 counties in Ireland, but the principal coal districts taken together only produced about 125,000 tons.

Thus there is coal enough in the British Islands to last more than a thousand years; and were it exhausted, our friends across the Atlantic have enough to supply the world for ages uncountable.[1]

The carboniferous strata are enormously developed in the States of North America. The Appalachian coal-field extends without interruption 720 miles, with a maximum breadth of 280 miles, from the northern border of Pennsylvania to near Huntsville, in Alabama, occupying an area of 63,000 square miles. It is intersected by three great navigable rivers—the Monongahela, the Alleghany, and the Ohio—which expose to view the seams of coal on their banks. The Pittsburg seam, 10 feet thick, exposed on the banks of the

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[1] There are 3224 collieries in Britain, in which 307,000 men and boys are employed: the greatest depth attained is 2500 feet, and many of the mines are of vast extent. The Workington and Whitehaven coal-mines extend a mile under the sea; several shafts in the latter are 100 fathoms deep; and it is one of the finest in England for extent and thickness of strata, some of the seams being nine feet thick, yielding in 1867 from 25 collieries 1,512,514 tons.

In the year 1867 the value of the mineral produce of Great Britain reached enormous amounts, namely—

	£
Silver	215,400
Copper	831,761
Iron	11,902,557
Lead	1,337,509
Tin	799,203
Zinc	79,693
Salt	836,963
Other metals and minerals ..	1,260,540
Coal	26,125,145
Total	£43,388,771

At present there are upwards of 104,000,000 of tons of coals raised in Great Britain annually, including the quantity exported to our colonies and to foreign countries, amounting to nearly 10,000,000 of tons.

The iron made in Britain in 1860 amounted to 10,021,058 tons.

The produce of our copper-mines has increased greatly within the last 60 years, and in 1867 amounted to 10,233 tons of pure metal. The quantity of tin has also increased from our own mines to 7296 tons in 1867, and also from the extensive importation of that metal from the Eastern Archipelago, where the country yielding stream-tin extends from 7° N. lat. to 3° S. lat. The produce from the latter country imported into Great Britain in 1867 amounted to 5428 tons of pure metal.

1,949,483 tons of British coal were imported into France in 1867.

Belgium is next in importance to England as a coal-producing country. In Britain the coal-fields occupy one-twentieth part of the area of the country—in Belgium one twenty-second part—in France one two hundred and tenth part of its area.

The quantity of coal raised in 1866 was—

In Belgium	12,774,662 tons.
„ Germany	27,000,000 „

Monongahela, extends horizontally 225 miles in length and 100 in breadth, and covers an area of 14,000 square miles, so that this seam of coal may be worked for ages almost on the surface, and in many places literally so. Indeed, the facility is so great that it is more profitable to convey the coal by water to New Orleans, 1100 miles distant, than to cut down the trees with which the country is covered for fuel, and which may be had for the expense of felling. The coal is bituminous, similar to the greater part of the British coal; forty miles to the E., however, among the ridges of the Appalachian chain, there is an extensive outlying member of the great coal-field, which yields anthracite, a species of coal which has the advantage of burning without smoke.

In the western States, the Illinois coal-field, which occupies part of Illinois, Indiana, and Kentucky, is as large as England, and consists of horizontal strata, with numerous seams of rich bituminous coal. There is a vast coal-field also in Michigan. Large areas in New Brunswick and Nova Scotia abound in coal, and good coal is worked at Nanaimo in Vancouver Island; 150 to 300 tons daily were taken out in 1867, near the Red River, and various other parts of British America. Iron is worked in many parts of the United States, from Connecticut to South Carolina.[1]

The tropical regions of the globe have been so little explored that no idea can be formed of the quantity of coal or iron they contain; but as iron is so universal, it is probable that coal is not wanting. It is found in Formosa. Both abound in Borneo, and in various parts of tropical Africa and America. There is comparatively so little land in the southern temperate zone, that the mineral produce must be more limited than in the northern, yet Australia, Tasmania, and New Zealand are rich in coal and iron.

§ 6. Arsenic, used in the arts and manufactures, is generally found combined with iron and sulphur in many countries as well as our own. Manganese, zinc, bismuth, and antimony are raised to a considerable amount. As the qualities of the greater part of the more rare metals are little known, they have hitherto been interesting chiefly to the mineralogist and chemist.

The mines of rock-salt in Cheshire seem to be inexhaustible. Enormous deposits of salt extend 600 miles on each side of the Carpathian mountains, and throughout wide districts in Austria, Gallicia, Tuscany, and Spain. It would not be easy to enumerate the places in Asia where rock-salt has been found. Armenia, Syria, and extensive tracts in the Punjab abound in it, also China and the Ural district; and the Andes contain vast deposits of rock-salt, some at great heights.

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[1] Sir Charles Lyell's 'Travels in the United States of North America.'

Volcanic countries in both continents yield sulphur. Italy and Sicily, where it is in the tertiary marine strata, are the magazines which supply the greater part of the manufactures of Europe. It is often beautifully crystallized. Asphalt, nitre, and alum are found in various parts of Europe and Asia; natron is procured from small lakes in an oasis on the W. of the Valley of the Nile; nitrate of soda, now extensively used in agriculture and in chemical manufactures, in the desert of Tarapaca, in Peru; and naphtha, or petroleum, in immense quantities, in Canada and the United States. Petroleum is also found in Wallachia, and in small quantities in Derbyshire, in England. The petroleum obtained from America must be distinguished from the paraffin and other mineral oils procured by the destructive distillation of coal and bituminous shale in England and Scotland.

§ 7. The diffusion of precious stones is very limited. Diamonds are found in a soil of sand and gravel, and in the beds of rivers. Brazil furnishes most of the diamonds of commerce; they are the produce of tracts on each side of the Sierra Espinhaço, and of a district watered by some of the affluents of the Rio São Francisco. During the century ending in 1822, diamonds were collected in Brazil to the value of 3,000,000*l*. sterling, one of which weighed 138½ carats. In 1863, a diamond weighing 254½ carats in its rough state was found by a negress in the Province of Minas Geraes. It is called the "Star of the South," and was shown at the Great Exhibition in London in 1862. The celebrated mines of Golconda have produced many splendid diamonds: they are also found in Borneo, which produced one weighing 367 carats, valued at 269,378*l*. The eastern parts of the Tian-Shan, on the great platform of Asia, and a wide district of the Ural Mountains, yield diamonds, and they have lately been found in the basin of the Orange River, in South Africa.

The ruby and sapphire, which have the same crystalline form, are found in Ceylon, in the gravel of streams. The rubies at Gharan, near to the river Oxus, are imbedded in limestone. The gravel of rivulets in the Birman empire contains the oriental, star, and opalescent rubies. The spinelle also occurs in that country in a district five days' journey from Ava. The blue, green, yellow, and white sapphires are the produce of the Birman empire.

The finest emeralds come from veins in a blue slate, of the age of our lower chalk strata, in the valley of Muzo, in New Granada.[1] Beryls are found in Brazil, and in the old mines in Mount Zebarah, in Upper Egypt. Those of Hungary and of the Heubach Valley, near Salzburg, are very inferior in colour and quality.

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[1] This curious geological fact has been established by the discoveries of Professor Lewy, who has sent to Paris specimens in which crystals of emerald and greensand fossils are imbedded.

Mexico, Hungary, and Bohemia yield the finest opals; the most esteemed are opaque, of a pale brown, and shine with the most brilliant iridescence; some are white, transparent, or semi-transparent, and radiant in colours. The most beautiful garnets come from Bohemia and Hungary; they are found in the Harz Mountains, Ceylon, and many other localities. The turquoise is a Persian gem, of which there are two varieties; one is supposed to be the enamel of the tooth of a fossilized mastodon, the other a purely mineral substance. Badakshan, in the Beloot-Tagh, is the principal locality of the lapis lazuli. This beautiful mineral is also found in several places of the Hindoo Koosh, in the hills of Istalif, N. of Cabool, in Tibet, and in the Baïkal mountains, in Siberia.

The cat's-eye is peculiar to Ceylon. Topazes, beryls, and amethysts are of very common occurrence, especially in Brazil and Siberia. They are little valued, and scarcely accounted gems. Agates are so beautiful on the table-land of Tibet, and in some parts of the desert of the Great Gobi, that they form a considerable article of commerce with China, and some are brought to Rome, where they are cut into cameos and intaglios. But the greater part of the agates, cornelians, and chalcedonies used in Europe are found in the trap-rocks round Oberstein, in the Palatinate.

Thus, by her unseen ministers, electricity and reciprocal action, the great artificer Nature has adorned the depths of the earth and the heart of the mountains with her most admirable works, filling the veins with metals, and building the atoms of matter, with the most elegant and delicate symmetry, into innumerable crystalline forms of inimitable grace and beauty. The calm and still exterior of the earth gives no indication of the activity that prevails in its bosom, where treasures are preparing to enrich future generations of man. Gold will still be sought for, and the diamond will be gathered among the débris of the mountains, while time endures.

CHAPTER XVIII.

THE OCEAN.

§ 1. Extent of the ocean; variation in depth; its colour and pressure. § 2. Saltness of the ocean; its point of congelation. § 3. Causes of tides; course of the tidal wave; waves arising from the friction of the wind. § 4. Currents, how caused; their direction; effects on voyages; great-circle sailing. § 5. Temperature of the ocean; stratum of constant temperature; line of maximum temperature. § 6. Icebergs; their size and danger to navigation; polar ice; submarine currents. § 7. The north-west passage; attempts to accomplish it; expeditions of Franklin, Collinson, and M'Clure; M'Clintock's discovery of the relics of the lost Franklin party. § 8. Inland seas; the Baltic, Black Sea, and Mediterranean; Sea of Okhotsk, Red Sea, Persian Gulf, &c.

§ 1. THE ocean, which fills a deep cavity in the globe, and covers three-fourths of its surface, is so unequally distributed that there is three times more land in the northern than in the southern hemisphere. The torrid zone is chiefly occupied by sea, and only one 13th part of the land on one side of the earth has land opposite to it on the other. The form assumed by this immense mass of water is that of a spheroid flattened at the poles; and as its mean level is nearly the same, for anything we know to the contrary, it serves as a base to which all heights of land are referred.

The ocean is continually receiving the spoils of the land. From that cause it would constantly be decreasing in depth, and, as the quantity of water is always the same, its superficial extent would increase. There are, however, counteracting causes to check this tendency: the secular elevation of the land over extensive tracts in many parts of the world is one of the most important. Volcanoes, coral islands, and barrier reefs, show that great changes of level are constantly taking place in the bed of the ocean itself—that symmetrical bands of subsidence and elevation extend alternately over an area equal to a hemisphere, from which it may be concluded that the balance is always maintained between the sea and land, although the distribution may vary in the lapse of time.[1]

The Pacific, or Great Ocean, exceeds in superficies all the dry land on the globe. It has an area of 50,000,000 of square miles; including the Indian Ocean, its area is nearly 70,000,000; and its breadth, from Peru to the coast of Africa, is 16,000 miles. Its length is less than that of the Atlantic, as it only communicates with the Arctic Ocean by Behring Strait, whereas the Atlantic, as far as we know, stretches from pole to pole.

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[1] Mr. Alfred Taylor has computed that all existing causes would produce an elevation of only three inches in 10,000 years.

The continent of Australia occupies a comparatively small portion of the Pacific, while innumerable islands stud its surface many degrees on either side of the equator, of which a great number are volcanic, showing that its bed has been, and indeed actually is, the theatre of violent igneous eruptions. So great is its depth that a line five miles long has not reached the bottom in many places; yet as the whole mass of the ocean counts for little in the total amount of terrestrial gravitation, its mean depth is but a small fraction of the radius of the globe; probably it is not more than three or four miles. The Pacific is the calmest of oceans; its tides are low, and its great currents broad and sluggish.

The bed of the Atlantic is a long deep valley, separating two vast continents, and probably extending from pole to pole. Its greatest breadth, including the Gulf of Mexico, is 5000 miles; its superficial extent is estimated at 25,000,000 of square miles. It is probably the most stormy sea in the world; its tides are high, and its principal currents narrow and swift. The bed of the South Atlantic has lately been sounded by vessels in the British Naval Survey, and bottom has been found between the Cape of Good Hope and Ascension Island, at depths varying from 10,800 to 17,400 feet; nearer the equator between 24° and 25° W. longitude the bed is much deeper, bottom being touched at 19,200 and 19,500 feet, and in mid-ocean on the parallel of 28° S., the depth was found to be 18,600 feet.[1] The great difficulties attendant on sounding vast depths of ocean have been overcome by Brooke's deep-sea sounding apparatus, which has enabled the officers of the United States navy to make an extensive and accurate survey of the North Atlantic. The greatest depths that the sounding-lead has reached in the North Atlantic are in the Sargasso Sea, lat. 26° N. and long. 60° W. where the sounding apparatus has revealed a depth of 22,950 feet. Hence from the top of Mount Everest, in the Himalaya, the highest ascertained point on the globe, to the deepest point of soundings is nearly 10 statute miles, estimated in a vertical line.

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[1] Pilot charts of the Atlantic Ocean, published by the Hydrographic Department of the Admiralty, under the superintendence of Captain G. H. Richards, R.N., the present Hydrographer. These charts illustrate winds, currents, and temperatures, as well as depths, and it is intended to produce similar magnificent works on the Pacific, the Indian, and other oceans.

Throughout the North Atlantic, the land shelves down to greater and greater depths gradually on both sides. On the coast of North America these submarine terraces seem to have a very regular and marked outline, the water increasing on them successively, leaving in the central parts the deepest portion. An extensive plateau of moderate depth extends from Newfoundland to the south of Ireland. Between Trinity Bay, in Newfoundland, and Valentia Island, Ireland, is laid the line of the Telegraph Cables, 1850 miles. In its deepest part, the ocean-bed on this plateau is not more than 14,400 feet in depth; but in many parts it is not deeper than 9000 to 10,000 feet. Such is the Telegraphic Plateau. On it are laid those stupendous cables which instantaneously convey intelligence from continent to continent, and which forms one of the boldest and noblest results of science. The subject of deep-sea sounding, and, in short, all that relates to what has been termed the Physical Geography of the Sea, is yet in its infancy. The early statements regarding unfathomable depths of ocean are to be received with much caution, as many of them have been disproved by actual experiment; thus in the very area, S. of the Bank of Newfoundland, where the greatest depth of the North Atlantic was supposed to exist, Commander Chimmo, of H.M.S. 'Gannet,' found, in 1868, bottom at 8700 feet. The question of the existence of living animals at great depths receives illustration by these surveys, and it is now admitted that the bed of the deepest sea is covered with minute living animals, such as Globigerinæ and others of low organization, who secrete calcareous matter, and are laying in the ocean depths the foundations of future geological formations similar to those of the great Cretacean Epoch.

Immense banks rise from great depths to within a few fathoms of the surface of the ocean. Of these, the Agulhas Banks, off the Cape of Good Hope, are among the most remarkable. But the double bank of Newfoundland is of still greater extent: it seems to have been formed by drift brought by an under current from the North Polar Ocean, as the water becomes suddenly deep at the southern extremity. The Dogger Bank, in the North Sea, and many others, are well known. According to Mr. Stevenson, one-fifth of the North Sea, an area equal to that of Great Britain, is occupied by banks whose average height is 78 feet. On that account the average depth is only 96 feet. Some of these elevations near the coast of Norway are surrounded by such deep water that they must be submarine table-lands. By soundings during the coast survey of the United Kingdom it appears that Great Britain, Ireland, and the innumerable islands and rocks that rise above the surface of the sea, repose upon a submarine bank bounded by a line 100 fathoms deep, and this bank, on which Great Britain and all its islands stand, is connected on the S.E. through Holland and Belgium with the continent of Europe, while it is separated from Norway and Sweden by a channel many hundreds of fathoms in depth. Some of the deepest wells in London and Sheerness draw their fresh water from a stratum which lies fully 300 feet below the surface of the submarine bank that intervenes between Britain and the coasts of Belgium, Holland, and Denmark.[1] Currents are sometimes deflected from their course by banks whose tops do not come within 50 or even 100 feet of the surface. Where banks or reefs rise to the surface in tropical seas, coco-nut palms have been planted by some of our cruizers to give warning of danger; as, for example, on a dangerous shoal off the coast of Brazil, called Las Roccas, lying about 120 miles west of Tristan d'Acunha.

The pressure at great depths is enormous. In the Arctic Ocean, where the specific gravity of the water is somewhat lessened, on account of the greater proportion of fresh water produced by the melting of the ice, the pressure at the depth of a mile and a quarter is 2809 pounds on a square inch of surface; this was confirmed by Captain Scoresby, who says, in his 'Arctic Voyages,' that the wood of a boat suddenly dragged to a great depth by a whale was found, when drawn up, so saturated with water forced into its pores that it sank in water like a stone for a year afterwards. Even sea-water is reduced in bulk from 20 to 19 cubic inches at the depth of 20 miles. The compression that a whale can endure is wonderful. Many species of fish are capable of sustaining great as well as sudden changes of pressure. Divers in the pearl-fisheries exert great muscular strength, but man cannot bear the increased pressure at great depths, because his lungs are filled with air, nor can he endure the diminution of it at great altitudes above the earth.

The depth to which the sun's light penetrates the ocean depends upon the transparency of the water, and cannot be less than twice the depth to which a person can see from the surface. In parts of the Arctic Ocean shells are distinctly seen at the depth of 80 fathoms; and among the West India islands, in 80 fathoms water, the bed of the sea is as clear as if seen in air; shells, corals, and seaweeds of every hue display the tints of the rainbow.[2]

The purest spring is not more limpid than the water of the ocean; it absorbs all the prismatic colours, except that of ultramarine, which, being reflected in every direction, imparts a hue approaching the azure of the sky. The depth of the blue depends upon the quantity of salt contained in the water. In salt-works the brine assumes a deeper blue the longer the evaporation is continued: that is the reason of the deep azure of the Mediterranean, the Gulf-stream, and the sea in the region of the trade-winds. In the Indian Ocean the colour is so intense that it has been poetically called the Black Waters. The light green of the North Sea and other polar waters is owing to the lesser proportion of salt.[1] The colour of the sea varies with every gleam of sunshine or passing cloud, although its true tint is always the same when seen sheltered from atmospheric influence. The reflection of a boat on the shady side is often of the clearest blue, while the surface of the water exposed to the sun is bright as burnished gold. The waters of the ocean also derive their colour from animalcules of the infusorial kind, vegetable substances, and minute particles of matter. It is white in the Gulf of Guinea; off California, the Vermilion Sea is so called on account of the red colour of the infusoria it contains; the same red colour was observed by Magellan near the mouth of the river Plate. The Persian Gulf is called the Green Sea by Eastern geographers, and there is a strip of green water off the Arabian coast so distinct that a ship has been seen in green and blue water at the same time. Rapid transitions take place in the Arctic Sea, from ultramarine to olive-green, from purity to opacity. These appearances are not delusive, but constant as to place and colour; the green is produced partly by its freshness, as well as by myriads of minute insects, which devour one another and are a prey of larger animals. The colour of clear shallow water depends upon that of its bed; over chalk or white sand it is apple-green, over yellow sand dark-green, brown or black over dark ground, and grey over mud.

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[1] Sir R. Murchison's Address, May 24, 1858.

[2] During the deep-sea dredging off the Atlantic coast of Ireland in 1869, innumerable instances of mollusca, crustacea, and other animals brilliantly coloured and with perfectly organized eyes, brought up from depths of 1230 and 1440 fathoms, give reason to believe that the bed of the ocean is not without light even at these profound depths.—*J. Gwyn Jeffreys, Esq.*

§ 2. The sea is supposed to have acquired its saline principle when the globe was in the act of subsiding from a gaseous state, for the water as well as the saline matter it contains is volatile and gaseous at high temperatures. The density of sea-water depends upon the quantity of saline matter it contains.[2] Commander Maury has computed, taking the average saltness at 3½ per cent., and the mean depth of the sea at two miles, that the quantity of saline matter contained in the ocean would cover an area of 7,000,000 square miles to the depth of one mile, a quantity that could not have been brought from the land by rivers and floods. The constituents of sea-water are everywhere the same, in consequence of the universal system of currents which prevails in the ocean by which the mass of waters are continually mixed. The differences depend upon local circumstances, especially evaporation. Thus the ocean contains more salt in the southern than in the northern hemisphere, which is supposed to arise from the south-eastern trade-winds blowing over a greater expanse of water than the north-eastern, and causing a greater evaporation. The greatest proportion of salt in the waters of the Pacific is between the parallels of 22° or 20° N. and 17° S. lat., the regions of the trade-winds; while near the equator, where these winds neutralize one another, it is less; and in the polar oceans it is the least, from the melting of the ice. The saltness varies in these regions with the seasons; the fresh water, being lightest, is uppermost. For the same reason rain makes the surface of the sea fresher than it is below, and the influx of rivers renders the ocean less salt near their estuaries. The Amazon renders the Atlantic brackish 300 miles from its mouth. The saltness of inland seas depends upon the quantity of fresh water they receive and the amount of evaporation. The Baltic is very fresh, because it has a limited evaporation at its surface, and receives many rivers. Though the Mediterranean receives large rivers, it is very salt from great evaporation; and the Red Sea, in a rainless region with great evaporation and no rivers, contains more salt than any other.[2]

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[1] Maury.

[2] According to Messrs. Schlagintweit the mean specific gravity of the surface-water of the Atlantic is 1·0277, and of the Pacific 1·0265, between 10° and 40° S.; and 1·02613 between 40° and 60°. The weight of a cubic foot of Atlantic water is 64·003 pounds.

Fresh water freezes at the temperature of 32° of Fahrenheit; the point of congelation of salt water is much lower. As the specific gravity of the water of the Greenland Sea is about 1·02664, it does not freeze till its temperature is reduced to 28½° of Fahrenheit, so that the saline principle preserves the sea in a liquid state to a much higher latitude than if it had been fresh,[2] while it is better suited for navigation by its greater buoyancy. The healthfulness of the sea is ascribed to the mixing of the water by tides and currents, which prevents the accumulation of putrescent matter.

Besides its saline ingredients, the sea contains bromine and iodine in very minute quantities, and, no doubt, portions of other substances too small to be detected by chemical analysis, since it has constantly received the débris of the land and all its organised matter.

§ 3. The tides which flow and ebb twice in a day on our coasts are raised by the combined action of the sun and moon. The water immediately under the moon is drawn from the earth by her attraction, at the same time that she draws the earth from the water

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[1] The solid contents of sea-water amount to about 3½ per cent. of its weight: they consist of common salt, or muriate of soda, of sulphates and carbonates of lime, magnesia, soda, potash, iron, and of a most minute quantity of silver.

[2] Fresh water acquires its maximum density at 39°·2, salt water (of the average saltness of the sea) at 27°·2.

diametrically opposite, in both cases producing a tide of nearly equal height. A similar action of the sun raises a wave, which, on account of his great distance, is very much less than that raised by the moon. The two waves sometimes unite, and sometimes are opposed to one another, according to the position of the luminaries; but the combined wave tends to follow the sun and moon as far as the rotation of the earth will allow, and extends to the very bottom of the sea. Being thus chiefly regulated by the moon, the tides happen twice in 24 hours, because in that time the rotation of the earth brings the same point of the ocean twice under the meridian of the moon—once under the upper meridian and once under the lower. It is clear that the highest or spring tides must happen at new and full moon, consequently twice in each lunar month, because in both cases the sun and moon are in the same meridian; for when the moon is new, they are in conjunction, and when she is full, they are in opposition, and in each of these positions their attraction is combined to raise the water to its greatest height; while, on the contrary, the neap or lowest tides happen when the moon is in quadrature, or 90° distant from the sun, for then they counteract each other's attraction.

Had the globe been entirely covered with water, the greatest tides would have taken place when the action of the sun and moon was in the plane of the equator and in the same meridian, for then their action would have been most direct; but in that case there would have been very small tides in the high latitudes and none at the poles, because then the action of the luminaries would decrease as the square of the cosine of their declination. That, however, is by no means the state of the tides, for, since the action of the sun and moon is only sensible in a vast extent of deep water, the Antarctic Ocean is their source and birthplace. The greatest spring tides, therefore, take place when the luminaries, in conjunction or opposition, are at their greatest southern declination, and the moon in perigee, that is, in the point of her orbit nearest to the earth.

When the sun and moon, under these circumstances, pass over the ocean to the E. of Tasmania, New Zealand, and the South Pole, they raise a vast ridge of water, or great tidal wave, which reaches to the very bottom of the sea and tends to follow the luminaries to the N.W., and, having received that primitive impulse, it continues to move in that direction long after the sun and moon cease to act upon it.

On entering the Pacific, it flows along the western coast of South America, bringing high water to each place as it passes: but it is so much impeded by the numerous islands in that ocean that it is scarcely perceptible in many places among them, whereas in the Indian Ocean it rushes with such violence and speed along the shores of the Indian peninsula that it arrives at Cape Comorin before noon of the first day of its existence, nearly at the same time that it has brought high water to the coast of Tasmania.

When this tidal wave enters the Atlantic in its north-westerly course, it brings high water later and later to each place; but its velocity is so very different on the two sides of that ocean that it arrives at Cape Blanco, on the W. coast of Africa, and at Newfoundland, on the E. coast of North America, at the end of the first 24 hours of its existence. It is then deflected to the E. by the continent of America, and thus, flowing at right angles to its former path, it comes to the most westerly points of Ireland and England on the morning of the second day. The great branch of this tidal wave then passes N.E. through St. George's Channel and the Irish Sea, and, meeting a branch coming round the W. coast of Ireland, the united wave, after having carried high water to the W. coast of England and all the coasts of Ireland, turns round the most northern point of Scotland and arrives at Aberdeen at noon on the second day, at the same time carrying high water to the opposite shores of Norway and Denmark. Now this tidal wave flows to the E. of S., a direction exactly contrary to that with which it began its transit through the Atlantic, and it continues this course, ruling the tides along the English shores and those of the opposite continental coasts, till it arrives at the mouth of the Thames at midnight of the second day, and does not bring high water to London till the morning of the third day after leaving the Antarctic Ocean.

The tidal wave moves uniformly and with great velocity in deep water, variably and slowly in shallow water. For example, it moves at the rate of 1000 miles an hour in the South Pacific, and scarcely less in the Atlantic, on account of the deep trough which runs through the middle of that ocean; but the sea is so shallow on the British coasts that the tide takes more time in coming from Aberdeen to London than to travel over an arc of 120°—that is, from 60° S. lat. to 60° N. lat.

There is such a numerical relation between the breadth and velocity of a wave and the depth of the water that, if the former be known, the depth may be computed. For example, if a wave moving at the rate of 12·21 miles in an hour be 1000 feet broad, the depth of the sea would be 10 feet by Mr. Airy's formula; but if a wave of the same breadth be moving at the rate of 48·77 miles, the sea would be 1000 feet deep. According to this law the South Pacific must be of great depth.

The tide in the open ocean is merely an alternate rise and fall of the water, so that the wave travels, but not the water. A bird resting on the surface is not carried forward as the waves rise and fall; indeed, if so heavy a body as water were to move at the rate of 1000 miles in an hour, it would cause universal destruction, since in the most violent hurricanes the velocity of the wind scarcely exceeds 100 miles in an hour.

During the passage of the wave in deep water, the particles of the fluid for the moment glide into a new arrangement, and then return to their places; but this motion is extremely limited. In the ocean the resistance of the bottom is imperceptible; but in shallow water, where the velocity of the wave is small, its lower parts are more retarded than those above, and, as the friction continually increases with the progress of the wave, its top advances more rapidly than the water below, so that over shallows and near the land both water and waves advance during the flow of the tide and roll on the beach.

The height to which the tides rise depends upon the form of the shores and bottom of the sea and the direction in which the wave strikes the land. Throughout the Atlantic the height is 10 or 12 feet; but the tidal wave rushes so directly into the Bay of Fundy that it rises to 50 feet, and from the shelving shores in the Bristol Channel it is 40 feet. When the tide enters the North Sea, to the N. of Scotland, its height is 12 feet; but in travelling S. along the E. coast of England over a continually shelving shore, and striking the land always more directly, the water rises higher and higher at each place till in the Humber it attains 20 feet.

It sometimes happens that two equal tides coming different ways meet, and then the water rises to double the height it would otherwise have done. A complete extinction of the tide takes place when a high water interferes in the same manner with a low water, as in the centre of the North Sea; a circumstance predicted by theory and confirmed by Captain Hewett, who was not aware that such an interference existed. When two unequal tides in contrary places meet, the greater overpowers the less, and the resulting height is equal to their difference, which is supposed to be the case at Yarmouth, where the tide is very small. These varieties occur chiefly in channels among islands and in the estuaries of rivers. When a tide flows suddenly up a river encumbered with shoals, it checks the descent of the stream; the water spreads over the sands, and a high-crested wave, called a bore, is driven with force up the channel. This occurs in the Hoogly mouth of the Ganges, and in the Amazon at the equinoxes, where, during three successive days, five of these destructive waves, from 12 to 15 feet high, follow one another up the river daily; and it occurs in a less degree in some of our British rivers.

Both the height and time of the tides vary with the moon's age.[1] The friction of the wind combines with the tides in agitating the surface of the ocean, and, according to the theory of undulations, each produces its effect independently of the other; wind, however, not only raises waves, but causes a transfer of superficial water also. Attraction between the particles of air and water, as well as the pressure of the atmosphere, brings its lower stratum into adhesive contact with the surface of the sea. If the motion of the wind be parallel to the surface, there will still be friction, but the water will be smooth as a mirror; but if it be inclined, in however small a degree, a ripple will appear. The friction raises a minute wave, whose elevation protects the water beyond it from the wind, which consequently impinges on the surface at a small distance beyond; thus each impulse, combining with the other, produces an undulation which continually advances.

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[1] Mr. Keith Johnston's Phys. Atlas, in folio.

Those beautiful silvery streaks on the surface of a tranquil sea, called cats'-paws by sailors, are owing to a partial deviation of the wind from a horizontal direction. The resistance of the water increases with the strength and inclination of the wind. The agitation at first extends little below the surface, but in long-continued gales even the deep water is troubled: the billows rise higher and higher, and, as the surface of the sea is driven before the wind, their "monstrous heads," impelled beyond the perpendicular, fall in wreaths of foam. Sometimes several waves overtake one another and form a sublime and awful sea. The highest waves known are those which occur during a N.W. gale off the Cape of Good Hope, aptly called by the ancient Portuguese navigators the Cape of Storms: Cape Horn also seems to be the abode of the tempest. The sublimity of the scene, united to the threatened danger, naturally leads to an over-estimate of the magnitude of the waves, which appear to rise mountains high, as they are proverbially said to do. There is every reason to believe that the waves off the Cape of Good Hope are occasionally 40 feet from the hollow trough to the summit, for the late Dr. Scoresby observed them to be of that height both in the Atlantic and during a cyclone he met with in his voyage to Australia in the Royal Charter.[1] The waves are short and abrupt in small shallow seas, and on that account are more dangerous than the long rolling billows of the wide ocean.

The waves raised by the wind are altogether independent of the tidal waves; each maintains its undisturbed course; and as the inequalities of the coasts reflect them in all directions, they modify those they encounter and offer new resistance to the wind, so that there may be three or four systems or series of coexisting waves, all going in different directions, while the individual waves of each maintain their parallelism.

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[1] Dr. Scoresby's Observations in the Atlantic, made with greater care than had been hitherto employed, confirm this result.—*Proceedings of British Association*, 1850.

The undulation called a ground-swell, occasioned by the continuance of a heavy gale, is totally different from the tossing of the billows, which is confined to the area vexed by the wind ; whereas the ground-swell is rapidly transmitted through the ocean to regions far beyond the direct influence of the gale that raised it, and it continues to heave the smooth and glassy surface of the deep long after the wind and the waves are at rest. In the South Pacific, billows which must have travelled 1000 miles against the trade-wind from the seat of the storm, expend their fury on the lee side of the many coral islands which bedeck that sunny sea.[1] Thus a swell sometimes comes from a quarter in direct opposition to the wind, and occasionally from various points of the compass at the same time, producing a vast commotion even in a dead calm, without ruffling the surface. They are the heralds that point out to the mariner the distant region where the tempest has howled, and not unfrequently they are the harbingers of its approach. At the margin of the polar ice, in addition to other dangers, there is generally a swell which would be very formidable to the mariner in thick weather, did not the loud grinding noise of the ice warn him of his approach.

Heavy swells are propagated through the ocean till they gradually subside from the friction of the water, or till the undulation is checked by the resistance of land, when they roll in surf to the shore, or dash in spray and foam over the rocks. The rollers at the Cape de Verd Islands are seen at a great distance approaching like mountains. When a gale is added to a ground-swell, the commotion is great and the force of the surge tremendous, tossing huge masses of rock and shaking the cliffs to their foundations. During heavy gales on the coast of Madras the surf breaks in nine fathoms water at the distance of four and even four and a half miles from the shore. The violence of the tempest is sometimes so intense as to quell the billows and scatter the water in a heavy shower called by sailors spoondrift. On such occasions saline particles have impregnated the air to the distance of 50 miles inland.

The force of the waves in gales of wind is tremendous. From experiments made by the late Mr. A. Stevenson, the celebrated engineer of the Skerryvore lighthouse, on the W. coast of Scotland, exposed to the whole fury of the Atlantic, it appears that the average pressure of the waves during the summer months was equal to 611 pounds weight on a square foot of surface, while in winter it was 2086 pounds, or three times as great. During the storm that took place on the 9th of March, 1845, it amounted to 6083 pounds.

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[1] Beechey's 'Voyage to the Pacific.'

Now, as the pressure of a wave 20 feet high not in motion is only about half a ton on a square foot, it shows how much of their force waves owe to their velocity. The rolling breakers on the cliffs on the W. coast of Ireland are magnificent: the Earl of Dunraven measured some, the spray of which rose as high as 150 feet.

In the Isle of Man a block, which weighed about 10 stone, was lifted from its place and carried inland during a north-westerly gale; and in the Hebrides a block of 42 tons weight was moved several feet by the force of the waves. The Bell Rock lighthouse in the North Sea, though 112 feet high, is literally buried in foam and spray to the very top during ground-swells when there is no wind. On the 20th of November, 1827, the spray rose 117 feet, so that the pressure was computed by Mr. Stevenson to be nearly three tons on a square foot.

The effect of a gale descends to a comparatively small distance below the surface; the sea is probably tranquil at the depth of 200 or 300 yards; were it not so, the water would be turbid, and marine animals would be destroyed. Anything that diminishes the friction of the wind smoothes the surface of the sea—for example, oil or a small stream of packed ice, which suppresses even a swell. When the air is moist, its attraction for water is diminished, and consequently so is the friction; hence the sea is not so rough in rainy as in dry weather.

§ 4. Currents of various extent, magnitude, and velocity disturb the tranquillity of the ocean; some of them depend upon circumstances permanent as the globe itself, others on ever-varying causes; the permanent and most important currents move in the great circles of the sphere. A perpetual circulation is kept up in the waters of the main by these vast marine streams; they are sometimes superficial and sometimes submarine, according as their density is greater or less than that of the surrounding sea. But although they depend upon the same cause as the trade-winds, they differ essentially in this respect, that, whereas the atmosphere is heated from below by its contact with the earth, and transmits the heat to the strata above, the sea is heated at its surface by the direct rays of the sun, which produces a strong and rapid evaporation, especially in the tropical regions of the ocean, where the sea greatly exceeds the land in extent.

It is computed that 186,240 cubic miles of water are annually raised from the surface of the globe in the form of vapour, chiefly from the intertropical seas, part of which is restored to them in rain, but by far the greater part is carried by the winds to water the land and feed all the rivers and streams on the surface of the earth. The enormous quantity of water thus carried off by evaporation in the warm seas, which amounts to 139,680 cubic miles in the Indian and Pacific Oceans alone, disturbs the equilibrium of the seas, but it is restored by a perpetual flux of cold water from each pole towards the equator, and in a minute degree by vertical circulation.

When these streams of cold water leave the poles, they flow directly towards the equator; but before proceeding far, their motion is deflected by the diurnal rotation of the earth. At the poles they have no rotatory motion, and, although they gain it more and more in their progress to the equator, which revolves at the rate of 1000 miles an hour, they arrive at the tropics before they have gained the same velocity of rotation with the intertropical ocean. On that account they are left behind, and consequently flow in a direction contrary to the diurnal rotation of the earth. Hence the whole surface of the ocean for 30 degrees on each side of the equator flows in a stream or current from E. to W. 3000 miles broad. The trade-winds, which constantly blow in one direction, combine to give this great equatorial current a mean velocity of 10 or 11 miles in 24 hours.[1]

As soon as the water at the surface of the tropical seas becomes denser and salter than that immediately below from the evaporation, it sinks down, leaving a new surface to be acted upon; and were it not for the inhabitants of the deep, the buoyancy of those seas would be impaired. Insignificant as they may seem, the mollusca, corallines, and other marine animals which abound in such myriads at the bottom of the sea, bear so important a part in these great operations of nature that Lieutenant Maury says, "they have power to put the whole sea in motion from the equator to the poles and from top to bottom." By abstracting the solid matter from the water to build those immense coral reefs and islands, marl-beds, shell-beds, and infusorial deposits of enormous magnitude, it becomes buoyant, rises to the top, and supplies the place of that which has gone down, and which, in its turn, furnishes material for new deposits, and a new supply of water for the surface, an alternation as permanent as the currents themselves, and one of the most wonderful and beautiful adaptations of small means to a great end. The direct heat of the sun also increases the buoyancy of the water which flows in superficial currents towards the poles; but in going from the equator, where the rotation of the earth is at its maximum, to the poles, where there is none, they are deflected more and more towards the west, and, gradually losing their warmth, they become heavy, sink down, and return again as undercurrents to join the equatorial stream. Thus polar currents flow to the equator, and equatorial currents flow to the poles, in a never-ending circuit coeval with the ocean itself, and which will be co-existent with it while time endures. This perpetual fluctuation of the waters of the ocean between the polar basins and the equator, as they become alternately warm and cold, is the cause of that admirable system of currents which combine with the winds to mitigate the cold of the frigid zone and temper the heat of the torrid.

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[1] Winds are named from the points whence they blow, currents exactly the reverse. An easterly wind comes from the east; whereas an easterly current comes from the west, and flows towards the east.

The equatorial current of the Pacific and Indian Ocean may be regarded as one mighty stream flowing from E. to W. through about 255 degrees of longitude. It crosses the Pacific in a current nearly 3500 miles broad, between the parallels of 26° S. and 24° N. lat., thus spreading over nearly one-third of the distance from pole to pole. Its breadth is much diminished in coming to the Indian Archipelago, as in the Indian Ocean it flows between the 10th and 20th degrees of S. latitude.

In the North Pacific there are many offsets from the main flow, but by far the most remarkable originates in the Indian Ocean. It is known as the Chinese current, or the North-Pacific Gulf-stream. It flows through the Strait of Malacca, and, after being joined by warm streams from the Java and China Seas, it passes into the Pacific between the Philippines and the coast of Asia; from thence it flows to temper the climate of the Aleutian Islands, and is lost in its progress towards the coast of North America. Between this and the coast of Japan a cold current comes from the sea of Okhotsk, which is as much celebrated for its fisheries as the cold stream which flows over the great banks of Newfoundland in the Atlantic. It causes dense fogs on the coasts of Jesso, the Kurile Islands, and Kamtchatka, for the same reason that the Gulf-stream occasions those on the banks of Newfoundland.

The two great oceans under consideration being all but land-locked to the N., the principal exchange of warm and cold water is between the southern side of the equatorial current and the Antarctic Ocean. The warm streams which that current sends off in the Indian Ocean, from water occasionally at the temperature of 90° Fahrenheit, must be of great magnitude. One of these leaves the main stream between Africa and Australia, and, flowing S., ends in a motionless sea of weeds similar to the grassy sea in the Atlantic.

The equatorial current in the Indian Ocean is divided as it approaches Madagascar; one part runs to the N.W., bends round the northern end of Madagascar, flows through the Mozambique Channel, and, being joined by the other branch, it doubles the Cape of Good Hope outside of the Agulhas Bank, and, meeting with a warm current from the Atlantic, they become lost further S. Cold currents from the Antarctic Ocean come on each side of the weedy sea, which sometimes bring icebergs as low as the 40th parallel. A branch of these cold currents, according to the observations of Captain Toynbee, striking the Cape from the S.W., runs northward along the W. coast of Africa, and is the cause of the cool seas and fogs at Walvisch Bay and other places on this coast.

In the South Pacific, Maury has discovered a very large branch which leaves the equatorial flow midway between the coast of America and Australia, and, after a winding course, trends to the Antarctic Sea. This current enabled Sir James Ross to penetrate farther to the S. than Captain Wilkes; it is the highway to the Antarctic Seas. On each side of it branch off cold currents from the S., one along the coast of Australia, and the other known as Humboldt's current, in some places nearly one thousand fathoms deep, which runs along the South American coast, tempering the heat of the rainless shores of Peru, and which is felt even at the equator for a distance of 3500 miles from the American coast. Between this current and the great equatorial stream lies the "Desolate Region," an area of the ocean that ships seldom crossed till the discovery of the gold-mines in Australia and the Guano islands of Peru. Whales rarely come near it; even the sea-birds which so frequently accompany ships in these southern seas abandon them on approaching it, and the sea itself is comparatively barren of animal life.

Drift-currents depend upon the winds. The Pacific is under the influence of the trade-winds, which produce constant currents; and the monsoons, which cause drift-currents, setting alternately in one direction and then in the other, prevail chiefly in the Indian Ocean. These periodic winds, depending on the seasons, regulate the navigation both in the Bay of Bengal and Arabian Sea. Temporary currents raised by partial evaporations, changes in atmospheric pressure, and very heavy rains are frequent in the tropical regions.

From the South Polar Ocean an ice-bearing current, passing E. of Cape Horn, brings icebergs even to 36° S. lat., as far as which they have been seen off the S. coast of Africa.

The equatorial Atlantic current pursues its western course, 160 miles broad, to mid-ocean, where it sends off the north-western branch, and, on arriving at San Roque, on the American coast, it is divided into the Brazil and Guiana currents, the first of which sets along the South American shores so strongly that it is not deflected by the mass of water flowing into it from the Rio de la Plata, yet it is lost before arriving at Cape Horn. The Guiana branch, by much the largest, undisturbed by the powerful rivers Amazon and Orinoco, flows to the West-Indian Islands; there it joins the main equatorial flow, and the united streams enter the Caribbean Sea, after a course of 4000 miles across the Atlantic, with a velocity varying with the seasons, but on an average about 30 miles in 24 hours. From the Caribbean Sea it sweeps round the Gulf of Mexico and rushes through the Strait of Florida, the mightiest and most beautiful oceanic river in existence; its source under the tropic of Cancer, its mouth in the Arctic Ocean. Its current is more rapid than those of the Mississippi or the Amazon, and its volume a thousand times as great. In the Strait of Florida it is 32 miles wide, 2220 feet deep, and flows at the rate of four miles an hour. Its waters are of the purest ultra-marine blue as far as the coasts of Carolina, and so completely is it separated from the sea through which it flows, so sharp the line of separation, that a ship may be seen at times half in the one and half in the other. It is of high temperature at the surface, being 86° of Fahrenheit at the strait of Bemini, and after running 3000 miles to the N. it still preserves a summer heat, yet its banks and bottom are cold. As it proceeds in its northern course, towards Newfoundland, it is deflected towards the E., affecting, as nearly as possible, a great circle of the sphere, the shortest distance between two points on its surface, which is the course of currents in general, whether of air or water, unless diverted by local circumstances. The Gulf-stream, in its course towards the British Islands, the North Sea, and the Frozen Ocean, follows this law. At Cape Hatteras it begins to increase in width, it is deflected nearly to the E. by the banks of Newfoundland, and between 38° and 40° W. long. it spreads out like a fan from the Canaries to the Arctic Ocean, one branch[1] sweeping round the W. coast of Iceland and the other N.E. to the coasts of Norway and Spitzbergen. The presence of these currents is recognised by their greater warmth, even among the polar ice, and in consequence of some of them the Spitzbergen Sea is six or seven degrees warmer at the depth of 200 fathoms than at the surface. Thus the warmth of that great oceanic river tempers the severity of the climates even to Spitzbergen, and, but for its mild influence, the shores of the British Isles would be very much colder than they now are. Maury says, though the warmth of the Gulf-stream diminishes as it runs N., the quantity of heat which it spreads over the Atlantic in a winter's day would be sufficient to raise the whole atmosphere that covers France and Great Britain from the freezing-point to summer-heat, which is the principal cause of the mildness and damp of Ireland and of the S. of England.

Towards the Azores a portion of the Gulf-stream bends round, and, after uniting with Rennell's current, from the British Channel, runs along the African coast, and rejoins the great equatorial flow, having made a circuit of 3800 miles with varying velocity, leaving a vast space of nearly motionless water between the Azores, the Canaries, and Cape de Verd Islands, of 260,000 square miles—almost six times as large as the whole of Germany. This great area is the Grassy or Sargasso Sea, so called from its being so thickly covered with the seaweed called the Fucus or Sargassum natans,[1] that at a certain distance it seems solid enough to walk upon. These seaweeds probably grow on the spot, but the great accumulation is partly due to the circumstance that everything that floats on the Gulf-stream, as well as the stream itself, trends to the E.; so the weeds and substances that come from other parts of the Atlantic to the Gulf-stream are carried across it to its eastern side. The bodies of animals and plants of unknown appearance to Columbus and his companions, brought to the Azores by this cause, suggested to that great man the idea of land beyond the Western Ocean, and thus led to the discovery of the New World.

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[1] Recently ascertained by Captain Irminger of the Danish navy.

It is a common practice with navigators to throw bottles overboard, containing the date and position of the ship. A chart has been formed, showing the direct course a number of these bottles have taken in the Atlantic, from which it appears that those thrown in south of 45° N. lat. arrive either at the Gulf of Mexico or the West Indies, and all those committed to the deep N. of that parallel reach the coasts of Europe by the Gulf-stream or its branches; Lieut. Maury mentions, however, an instance of a bottle thrown overboard from an American ship off Cape Horn, in 1837, being lately found on the coast of Ireland. It appears that the Gulf-stream takes eight months to flow from the Gulf of Mexico to the shores of Europe, and that the broader and slower current takes 12 months to travel from the Bay of Biscay back to the Gulf of Mexico, periods which closely accord with the time occupied by the drift of bottles.

In the Atlantic the trade-winds only blow steadily between the parallels of 23° N. and 9° S. lat., and between these limits drift-currents run with a velocity of from 9 to 10 miles in 24 hours. In the calm regions these currents are very feeble, and in the extra-tropical seas, like the prevailing winds, the drift-currents are not so steady, they do not always flow in the same direction, nor with the same velocity.

In summer the great north polar current descending along the E. coast of Greenland, together with the current from Davis Strait, bring icebergs to the margin of the Gulf-stream. The difference between the temperatures of these two oceanic streams at their contact is the cause of the dense fogs that hang over the banks of Newfoundland. The north polar current runs inside of the Gulf-stream, along the coast of North America to Florida, and beyond it, since it sends an under-current into the Caribbean Sea. As early as the year 1838 Mr. W. C. Redfield had declared it to be his opinion that the Arctic current, after passing the banks of Newfoundland, flows beneath the Gulf-stream to the S. and S.W., a theory that has been confirmed by the American navigators, who have found that at the depth of 370 fathoms the bed of the Gulf-stream, in its warmest and narrowest part, has the temperature at 32°, so that it flows on a cushion of cold water. In longitude 46° W., Commander Dayman found that the water had a temperature of 39°·7 at a depth of 1000 fathoms in two instances, showing a remarkable contrast at so small a distance; but water of the temperature of 30° has been found at great depths by Dr. Carpenter much farther E. The current of cold water that extends from Cape Hatteras to the S.E. of the Bermuda Islands, as well as the cold bands found in the Gulf-stream, are no doubt detached portions of the Arctic current. The fish which abound to excess in this cold current never enter the Gulf-stream, whose existence was made known by the whales avoiding its warm waters. Counter-currents on the surface are of such frequent occurrence that there is scarcely a strait joining two seas that does not furnish one—a current running in along one shore, and a counter-current running out along the other. One of the most remarkable occurs in the Atlantic: it begins off the coast of France, and, after sending a mass of water into the Mediterranean, it follows a southerly direction at some distance from the continent of Africa; till, after passing Cape Mesurada, it flows rapidly for 1000 miles due E. to the Bight of Biafra, in immediate contact with the equatorial current, running with great velocity in the opposite direction; it appears finally to merge in the latter.

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[1] The Macrocystis pyrifera is also found in the Grassy Sea: the stem is not thicker than a man's finger, but from 1000 to 1500 feet long, branching upwards in filaments like packthread.

Periodical currents are frequent in the eastern seas: one flows into the Red Sea from October to May, and out of it from May to October. In the Persian Gulf this order is reversed; in the Indian Ocean and China Sea the waters are driven alternately in opposite directions by the monsoons. It is the south-westerly monsoon that causes inundations in the Ganges, and a tremendous surf on the coast of Coromandel. The tides also produce periodical currents on the coasts and in straits, the water running in one direction during the flood, and the contrary way in the ebb. The Roost of Sumburgh, at the southern promontory of Shetland, runs at the rate of 15 miles an hour; indeed the strongest tidal currents known are among the Orkney and Shetland islands; their great velocity arises from local circumstances. Currents in the wide ocean move at the rate of from one to three miles an hour in their centre; but the velocity is less at the sides and bottom of the stream, on account of friction.[1]

Whirlpools are produced by opposing winds and tides; the whirlpool of Maelström, on the coast of Norway, is occasioned by the meeting of tidal currents round the islands of Lofoden and Mosköe; it is a mile and a half in diameter, and so violent that its roar is heard at the distance of several leagues. But the danger to be apprehended from it has been much exaggerated.

What with winds, tides, and currents, the ocean is never at rest. Even in the equatorial regions, far from land, where dead calms prevail, and the sea is apparently in the most perfect stillness, day after day partaking of the universal quiet, yet it heaves its low flat waves in noiseless and regular periods: the ocean is only asleep, its pulse continues to beat, and evaporation keeps the particles of its glassy surface in ceaseless motion.

The calm of the equatorial sea is sometimes disturbed by a superficial tumult in the water called tide-rips, which move along with a threatening aspect and roaring noise.

The safety and length of a voyage depend upon the skill with which the navigator avails himself of the set of the different currents, and the direction of the permanent and periodical winds; it is frequently shortened by following a very circuitous track to take advantage of them if favourable, or to avoid them if unfavourable. From Acapulco, in Mexico, across the Pacific to Manilla or Canton, the trade-wind and the equatorial current are so favourable that the voyage is accomplished in 50 or 60 days; whereas, in returning, 90 or 100 are required. Within the Antilles navigation is so difficult from winds and currents that a vessel going from Jamaica to the Lesser Antilles cannot sail directly across the Caribbean Sea, but must go round about through the windward passage between Cuba and Haiti to the ocean; nearly as many weeks are requisite to accomplish this voyage as it takes days to return. On account of the prevalence of westerly winds in the North Atlantic, the voyage from Europe to the United States is longer than that from the latter to Europe; the Gulf-stream is avoided in the outward voyage, and advantage taken of it in returning. Ships going to the West Indies, Central or South America, from Europe, generally make the Canary Islands in order to fall in with the N.E. trade-winds, which carry them to within 10 degrees of the equator.

The passage to the Cape of Good Hope from Great Britain may be undertaken at any season, and is accomplished in 50 or 60 days; but it is necessary to regulate the voyage from the Cape to India and China according to the season of the monsoons. There are various courses adopted for that purpose, but all of them pass through the very focus of the hurricane district, which includes the islands of Rodriguez, Mauritius, and Bourbon, and extends from Madagascar to the island of Timor.

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[1] The reader is referred to the works of Lieut. Maury and Mr. Keith Johnston, already mentioned, for a more extensive account of currents in the ocean.

The shortest distance between any two points on the surface of the globe is the arc of a great circle; hence the length of a voyage will depend upon the skill in keeping that line as nearly as the winds and currents will permit, but the currents either do or tend to follow that line. The physical geography of the sea is now sufficiently well known to enable the mariner, by the aid of charts of the winds and currents, to pursue his course across the trackless ocean with as much confidence and certainty as if it were a railway. Commander Maury gives an instance of two large ships which left New York for California, a distance of 15,000 miles. One, which was the fastest sailer, set out nine days later, overtook and spoke to the other off Cape Horn, passed on, and arrived first. They were unconnected, but running against time; and after the voyage, when their courses were laid down on the chart, they were all but identical. Another instance is given of a race between three vessels going the same long voyage, quite unconnected, who yet, amidst all the vicissitudes of climate, winds, and currents, passed, repassed, and frequently recognised each other, as if they had been on a racecourse.

§ 5. Since water is a bad conductor of heat, the temperature of the ocean is less liable to sudden changes than the atmosphere; the influence of the seasons is imperceptible at the depth of 200 feet; and the direct heat of the sun does not affect the bottom of a deep sea. From recent observations of deep-sea temperatures in the Arabian Sea and other parts of the ocean, it is probable that there is a uniform temperature of 30° Fahr., or even lower, at great depths, provided the bed of the ocean permits free communication between the polar seas and these depths. Mr. Buchan[1] remarks, "It must be kept in mind that the whole water of the seas over the globe is one body; and on account of its fluidity a free communication is kept up among its different parts; and, since sea-water contracts, and consequently gains in density, as it is cooled until it freezes, the cold water tends everywhere to flow towards and settle in the depths of the ocean. From this it follows that the water of the sea will, below a certain depth, fall to one uniform temperature, and *that temperature just as cold as the surface temperatures of the*

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[1] 'Handy Book of Meteorology.'

sea over the whole globe can reduce it to." As the maximum density of salt water is 27°·2, it follows that the deep-sea temperature of polar regions cannot fall below 27°·2. Whether the temperature at great depths in lower latitudes is maintained at this point remains to be proved by observations made with the recently invented Miller-Casella thermometer.

The temperature of the surface of the ocean decreases from the equator to the poles. For 10 degrees on each side of that line the maximum is 84°·5 E. of New Guinea; from thence to each tropic the decrease varies considerably. The tropical temperature would be greater were it not for the currents. In the torrid zone the surface of the sea is about 3° of Fahrenheit warmer than the air above it, because the polar winds, and the great evaporation which abstracts the heat, prevent equilibrium; and as a great mass of water is slow in following the changes in the atmosphere, the vicissitude of day and night has little influence, whereas in the temperate zones it is perceptible.

The line of maximum temperature, or that which passes through all the points of greatest heat in the ocean, is very irregular, and does not coincide with the terrestrial equator; six-tenths of its extent lie on an average 5° to the N. of it, and the remainder runs at a mean distance of 3° on its southern side. It cuts the terrestrial equator in the middle of the Pacific Ocean in 120° W. longitude in passing from the northern to the southern hemisphere, and again through the Solomon Islands in returning from the southern to the northern. Its maximum temperature in the Pacific is 84°·5 of Fahrenheit on the eastern shores of New Guinea, where it touches the terrestrial equator, and its highest temperature in the Atlantic, which is 83°·5, lies in the Caribbean Sea, off Belize, which furnishes the warm water of the Gulf-stream.

The superficial water of the Pacific is much cooled on the E. by the Antarctic or Humboldt's current. It is about 10° colder than the adjacent ocean, and renders the air much cooler than the surrounding atmosphere.

In the Indian Ocean the highest temperature of the surface-water (82°·9) is in the Arabian Sea, between the coast of Africa and Ceylon.

The superficial temperature diminishes from the tropics with the increase of the latitude more rapidly in the southern than in the northern hemisphere.

§ 6. Icebergs come to a lower latitude by 10° from the south pole than from the N.; they have been seen near the Cape of Good Hope, and are often of great size; one observed by the late Admiral Dumont d'Urville was 13 miles long, with perpendicular sides 100 feet high above the water: they are less varied in shape than those in the northern seas. The discovery ships under the command of Sir James Ross met with multitudes with flat surfaces, bounded by perpendicular cliffs on every side, from 100 to 180 feet high, sometimes several miles in circumference. Their size must have been enormous, since more than two-thirds of their mass was below water. From the condensation of moisture in the surrounding air by their cold, they are often enveloped in mist, which makes them still more formidable to navigators. On one occasion the latter officer fell in with a chain of stupendous bergs close to one another, extending farther than the eye could reach even from the mast-head. Packed ice too is often in immense quantities: these ships forced their way through a pack 1000 miles broad, often under the most appalling circumstances. It generally consists of smaller pieces than the packs in the comparatively tranquil north polar seas, where they are often several miles in diameter, and where fields of ice extend beyond the reach of vision. The Antarctic Ocean, on the contrary, is almost always agitated; there is a perpetual swell, and terrific storms are common, which break up the ice and render navigation perilous. The floe pieces are rarely a quarter of a mile in circumference, and generally much smaller.

A more dreadful situation can hardly be imagined than that of ships beset during a tempest in a dense pack of ice in a dark night, thick fog, and drifting snow, with the spray beating perpetually over the decks and freezing instantaneously. Sir James Ross's own words can alone give an idea of the terrors of one of the many gales which the two ships under his command encountered:—" Soon after midnight our ships were involved in an ocean of rolling fragments of ice, hard as floating rocks of granite, which were dashed against them by the waves with so much violence that their masts quivered as if they would fall at every successive blow; and the destruction of the ships seemed inevitable from the tremendous shocks they received. In the early part of the storm the rudder of the Erebus was so much damaged as to be no longer of any use; and about the same time I was informed by signal that the Terror's was completely destroyed and nearly torn away from the stern-post. Hour passed away after hour without the least mitigation of the awful circumstances in which we were placed. The loud crashing noise of the straining and working of the timbers and decks, as they were driven against some of the heavier pieces of ice, which all the exertions of our people could not prevent, was sufficient to fill the stoutest heart, that was not supported by trust in Him who controls all events, with dismay; and I should commit an act of injustice to my companions if I did not express my admiration of their conduct on this trying occasion. Throughout a period of 28 hours, during any one of which there appeared to be very little hope that we should live to see another, the coolness, steady obedience, and untiring exertions of each individual were every way worthy of British seamen.

"The storm gained its height at 2 P.M., when the barometer stood at 28·40 inches, and after that time began to rise. Although we had been forced many miles deeper into the pack, we could not perceive that the swell had at all subsided, our ships still rolling and groaning amidst the heavy fragments of crushing bergs, over which the ocean rolled its mountainous waves, throwing huge masses upon one another, and then again burying them deep beneath its foaming waters, dashing and grinding them together with fearful violence."

For three successive years were these dangers encountered during this bold and hazardous enterprise. It was impossible to pass the winter in these southern seas, but in the various expeditions to the North Polar Ocean the ships were frozen fast in boundless fields of ice for many months, ready to continue their perilous voyage as soon as the late and short summer should break it up.

The surface of the Arctic Ocean, filling the area of a circle of between 3000 and 4000 miles in diameter, is always at the freezing-point of fresh-water, and in winter it is encircled by a zone of ice probably not extending much beyond 82° of N. lat., as there is every reason to believe that there is an open ocean in the vicinity of the pole. The outline of this zone, though subject to partial variations, is found to be nearly similar at the same season of each succeeding year, yet there are periodical changes in the ice which are renewed after a series of years. The freezing process itself is a bar to the unlimited increase of the oceanic ice. Fresh-water congeals at the temperature of 32° of Fahrenheit, but sea-water must be reduced to $27^{\circ}\cdot2$ before it deposits its salt and begins to freeze: the salt thus set free, and the heat given out, retard the process of congelation more and more below. The ice from the N. extends so far S. in winter as to render the coast of Newfoundland inaccessible; it envelops Greenland, sometimes even Iceland, and always invests Spitzbergen and Novaia Zemlia.

As the sun comes N. the zone of ice breaks up into enormous masses of what is called packed ice. Floating fields of ice, 20 or 30 miles in diameter, are frequent in the Arctic Ocean: sometimes they extend 100 miles, so closely packed together that no opening is left between them: their thickness, which varies from 10 to 40 feet, is not seen, as there is at least two-thirds of the mass below water. Sometimes these fields, many thousand millions of tons in weight, acquire a rotatory motion of great velocity, dashing against one another with a tremendous collision. Packed ice always has a tendency to drift southwards even in the calmest weather; and in their progress the ice-fields are rent in pieces by the swell of the sea. It is computed that 20,000 square miles of drift-ice are annually brought by the current along the coast of Greenland to Cape Farewell. In stormy weather the fields and streams of ice are covered with haze and spray from constant tremendous concussions; yet our seamen, undismayed by the appalling danger, boldly steer their ships amidst this hideous and discordant tumult.

Huge icebergs detached from enormous masses of ice that fill the Greenland fiords are drifted southward 2000 miles to melt in the Atlantic, where they cool the water for 30 or 40 miles around, and the air to a much greater distance. They vary from a few yards to miles in circumference, and rise several hundred feet above the surface. Seven hundred such masses have been seen at once in the polar basin. When there is a swell, the loose ice dashing against them raises the spray to their very summits, and as they waste away, they sometimes lose their equilibrium and roll over, causing a swell which breaks up the neighbouring field-ice; the commotion spreads far and wide, and the uproar resounds like thunder.

Icebergs have the appearance of chalk-cliffs with a glittering surface and emerald-green fractures. Pools of azure-blue water lie on their surface, or fall in cascades from them. The field-ice also, and the masses that are heaped upon its surface, are extremely beautiful from the vividness and contrast of their colouring. A peculiar blackness in the atmosphere round a bright haze at the horizon indicates their position in a fog, and their place and character are shown at night by the reflection of the *snow-light* on the horizon. An experienced seaman can readily distinguish by the *blink*, as it is termed, whether the ice is newly formed, heavy, compact, or open. The blink, or snow-light, of field-ice is the most lucid and is tinged with yellow; of packed ice it is pure white; ice newly formed has a greyish blink; and a deep-yellow tint indicates snow on land.

The Pacific is only connected with the Arctic Ocean by Behring Strait, through which narrow channel a surface-current sets to the N.; but the Atlantic penetrates far beyond the Arctic Circle to the E. of Greenland, and also into Davis Strait, which last spreads out into Baffin Bay, twice the size of the Baltic, very deep, and subject to all the rigours of an Arctic winter, the very storehouse of icebergs, the abode of the walrus and the whale; Baffin Bay itself is but the highway by Smith Sound to the Polar Ocean, which in its northern prolongation occupies an area of a million and a half of square miles as yet unexplored.

There is a perpetual circulation of water between the Arctic Ocean and the Atlantic. Currents of cold water flow southwards on the surface of the Arctic Ocean into the Atlantic, while submarine currents of warmer water come from the Atlantic to the Arctic Seas: the freshness of the former, from the melting of the ice as the sun travels N., making it buoyant, though cold; and the saltness of the other making it heavy, though comparatively warm. But in time the qualities of each are changed, and they return to the oceans whence they came to maintain the equilibrium of the seas.

The surface-current must be extremely powerful, for a field of ice, 300,000 square miles in extent, carried the Resolute firmly fixed in it for 1000 miles to the S. The Resolute had been abandoned by Captain Kellett some years before sealed up in that mass of ice, at Melville Island, and was found in the midst of Baffin Bay by some American whalers, by whom she was taken to the United States, purchased by the government of that country, and courteously restored to Her Majesty. Lieutenant De Haven, who was generously sent in the brig Advance by the United States in search of Sir John Franklin, was frozen up for nine months in a field of ice of equal magnitude mid-channel in Davis Strait, and was carried by the current to the S. for 1000 miles. The average thickness of the ice was seven feet, and Maury computed that an area of ice of 300,000 square miles seven feet thick would weigh 18 billions of tons, and that a quantity of water many times greater would be required to float or drive this mass through Davis Strait.

§ 7. The Russians would be saved a voyage of 18,800 geographical miles could they cross the pole and pass through Behring Strait to their North Pacific settlements instead of going by Cape Horn; and a direct course from the Thames, across the north pole, to Behring Strait, would only be 3570 geographical miles. But even if the pole could not be attained, it would evidently be of the greatest advantage to all the maritime nations of Europe were it possible to sail from the Atlantic to the Pacific Ocean by the northern coasts of America. The hopes of being able to accomplish this north-western passage has led to numerous voyages in which the highest qualities and virtues of man have been displayed.

War had for many years put a stop to enterprise when Dr. Scoresby, on a whaling voyage with his father in 1806, reached the parallel of 81° 30′ N., midway between Greenland and Spitzbergen, where the sea was open for 18,000 square miles, and he afterwards found the E. coast of Greenland, hitherto supposed to be inaccessible, free from ice from 70° to 80° N. lat., and for 10° of longitude. In consequence of these discoveries the hope of penetrating to the Arctic Ocean revived, and in 1818 four ships were sent by the British Government to find their way N. about to Behring Strait; two, commanded by Captains Parry and Ross, were to proceed by Davis Strait, and the other two, under the command of Captains

Buchan and Franklin, by the open sea at Spitzbergen across the pole. Both failed in the object of their mission, and from that time to 1845 numerous similar attempts were made without success. After spending years in these dreary regions, they all returned baffled by impenetrable barriers of ice, not however without having made important discoveries both in geography and general science.

As it is not in the nature of the Anglo-Saxon race lightly to give up anything they have once undertaken, so in 1845 a new expedition was planned, and a great number of volunteers, both of men and officers, offered to embark for the ice-bound seas of the N., notwithstanding the sufferings and dangers which they knew awaited them, and which many of them had already experienced.

The command offered by the Admiralty was joyfully accepted by Sir John Franklin, on his return from having governed Tasmania for several years. He was an honour even to the British navy, where there is so much honour. Besides long voyages in various parts of the world, he had in former years made two in the Arctic Seas, so he was perfectly acquainted with all that is requisite for that difficult navigation.

The expedition consisted of two screw steamers, perfectly equipped and prepared to resist the pressure of the ice, furnished with everything that was necessary, and a transport accompanied them to Davis Strait to complete their supply of provisions. Sir John commanded the Erebus, and Captain Crosier, who had been second in command in the Antarctic Seas with Sir James Ross, and had made two Arctic voyages with Sir Edward Parry, commanded the Terror. Their orders were to proceed by Lancaster Sound and Barrow Strait to 74° 30′ N. lat., from thence to make Cape Walker in 98° W. long., and then to find their way to Behring Strait. They sailed from the Thames on the 19th of May, and arrived in safety at Whalefish Island on the E. coast of Davis Strait. There they wrote the last letters that ever were received from them, and the ships were seen for the last time on the 26th of July by the Prince of Wales whaler, moored to a floating mass of ice in 76° 48′ N. lat. and 66° 13′ W. long.

Although it was known that the voyage would last more than one year, yet fears were felt for their safety as early as 1848, and from that time one expedition after another was sent, some by Davis and others by Behring Strait; yet with all the advantages of scientific knowledge, steam, and practical skill, the intricacies of these frozen seas were searched in vain, though searched with the zeal of affection and friendship. Lady Franklin, for whom every one felt the deepest sympathy, sent two ships and aided in the equipment of a third; her long-continued hope and energy lasted long after all hope was at an end. Even after the lapse of more than 11 years her affection induced her to send a steamer to the Arctic Seas, trusting that the crews might still exist among the horde of Esquimaux, or that some relics of them might be found should they have perished.

Two of the expeditions were attended by great and important results. The Enterprise and Investigator, commanded by Captains Collinson and M‘Clure, sailed on the 10th of January, 1850, for Behring Strait. Captain M‘Clure in the Investigator arrived first, passed through the strait, and with great difficulty, touching at Capes Barrow and Parry, steered N. through an open sea to an unknown land, which turned out to be Banks Land, or island, so named by Sir Edward Parry, who had seen its northern coast during the memorable winter he spent at Melville Island. Captain M‘Clure then sailed through a strait between that island and Prince Albert Land to 73° N. lat., since called Prince of Wales Strait. Being prevented by ice from proceeding farther, Captain M‘Clure turned back, and was frozen up in the strait for nine months. During that time excursions were made in various directions in search of the missing ships, but in vain. In one of these excursions it was found that Prince of Wales Strait opened into Barrow Gulf, which leads by the straits of Barrow and Lancaster into Baffin Bay; and as these latter had been previously examined from the eastward by Parry and others, this discovery settled the question of the N.W. passage, which Captain M‘Clure has had the honour of having effected—the object of so many voyages of peril and suffering.

In the late spring of 1852 the Investigator was released from its icy prison, but, finding it impossible to enter Barrow Gulf, and wishing to reach Melville Island before another winter, Captain M‘Clure sailed round the W. side of Banks Land, but could get no farther than a deep bay on the N. side, where he wintered, and to which he gave the name of the Bay of God's Mercy. After being so long at sea, their provisions began to fail, but at first the deer and musk oxen, which abound in the island, furnished them with plenty of food; however, the winters of 1852-3 were uncommonly severe, the men had to go far in chase of these animals, by degrees their strength failed, they became low, sickly, and dispirited. It was an arduous journey of 10 days over the ice to Melville Island, nevertheless Captain M‘Clure effected it without any loss, and deposited a paper at the spot where Sir Edward Parry had passed a winter, in which he gave information of his situation, begged for aid, and requested that those who might find it would forward it to England. At the same time, impressed, after his long imprisonment in the ice, that some decisive step should be taken for their rescue, it was determined that one part of the crew, under command of the first lieutenant, should find their way to M‘Kenzie

River, and that with the rest the captain should patiently await the breaking up of the ice, and endeavour to navigate the ship to Baffin Bay.

Anxiety now began to be felt for the fate of this expedition also, and another, consisting of four ships, sailed from England under the command of Sir Edward Belcher in April 1852, for Davis Strait. Two of the vessels were to go in search of Sir John Franklin; the others, including the Resolute, commanded by Captain Kellett, had orders to deposit provisions in Melville Island for the Enterprise and Investigator, should they call there. On arriving they found the documents deposited by Captain M'Clure, and a party soon after set out to discover if he was still in the Bay of Mercy.

On the day before their intended separation (April 19th, 1853), Captain M'Clure and his first lieutenant were walking on the ice, when they saw a man running, and thought it one of the crew chased by a bear—it was Lieut. Pim of the Resolute. Words fail to describe that meeting—they were at last rescued from their perils. The joy of the ship's company and their gratitude to God for their deliverance were unbounded.

The sequel of this remarkable expedition may be told in a few words. Means were immediately adopted for conveying over the ice to Melville Island the Investigator's exhausted crew, where they arrived in June: a portion remained there, the most robust having proceeded to the general rendezvous at Beechey Island. All, however, were destined to spend another dreary winter in the ice; but on Sir Edward Belcher's much criticised measure of ordering the abandonment of all the ships under his orders engaged in the search for Franklin in May, their united crews, including that of the Investigator, embarked for England, which they reached in the autumn of 1854.

Not discouraged by so many failures, Lady Franklin fitted out a fourth expedition, under the command of Captain (now Sir Leopold) M'Clintock, who sailed from Aberdeen in the Fox on the 17th July, 1857. His ship was beset by ice between Melville Bay and Lancaster Sound, and drifted back with the ice through 1194 geographical miles. On the breaking up of the ice, Captain M'Clintock continued his voyage and research under circumstances of great peril, but it was not till the spring of 1860 that any traces of the lost expedition were obtained. On the north-western shore of King William's Island, so desolate that even the wandering Esquimaux never approach it, a tin case that had been buried in a cairn 12 years before was discovered. It contained a written document in which it was recorded that Sir John Franklin died on the 11th June 1847, that the ships had been abandoned about 15 miles to the N.N.W. of that desert island, and that 105 of the survivors intended to proceed next day to Back's Fish River and must have perished on the way. Of the 2000 miles of ocean forming the N.W. passage between the Atlantic and Pacific, no less than 1260 miles had been investigated under the command of Sir John Franklin either by ship or boat, and in this last and fatal voyage 560 miles of unknown sea had been navigated; so that he and his companions have the honour of being the first who have made the N.W. passage, but the way was prepared by the numerous brave men who had navigated these ice-clad seas for 40 years. Captain M'Clintock and his officers have discovered 600 miles of new coast-line of North America, which completes our geographic knowledge of the Arctic limits of that continent.

§ 8. The ocean is one mass of water, which, entering into the interior of the continents, has formed seas and gulfs of great magnitude, which afford easy and rapid means of communication, while they temper the climates of the widely expanding continents.

The inland seas communicating with the Atlantic are larger, and penetrate more deeply into the continents, than those connected with the great ocean; a circumstance which gives a coast-line of 48,000 miles in extent to the former, while that of the great ocean is only 44,000. Most of these internal seas have extensive river tributaries, so that by inland navigation the Atlantic virtually enters into the deepest recesses of the land, brings remote regions into contact, and improves the condition of the less cultivated races of mankind by commercial intercourse with those that are more civilized.

The Baltic, which occupies 125,000 square miles in the centre of northern Europe, is one of the most important of the inland seas connected with the Atlantic, and, although inferior to the others in size, the drainage of more than a fifth of Europe flows into it. Only about a fourth part of the boundary of its enormous basin of 900,000 square miles is mountainous; and so many navigable rivers flow into it from the watershed of the great European plain, that its waters are nearly one-fourth less salt than those of the Atlantic: it receives at least 250 streams. Its depth nowhere exceeds 167 fathoms,[1] and generally it is not more than 40 or 50. From that cause, together with its freshness and its higher northern latitude, the Baltic is frozen during five months in the year.

From the flatness of the greater part of the adjacent country, the climate of the Baltic is subject to influences that have their origin in regions far beyond the limits of its river-basin. The winds from the Atlantic bring warmth and moisture, which, condensed by the cold blasts from the Arctic plains, falls in rain in summer, and deep snow in winter, which diminishes its saltness, but an under and salter current flows into the Baltic through the Sound. Regular tides in the Baltic are imperceptible; but the waters occasionally rise more than three feet above their usual level from some unknown cause—possibly from subterranean oscillations in its bed, or from changes of atmospheric pressure.

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[1] By Captain Albrecht's soundings.

The Black Sea, which penetrates deeply into the continent, has, together with the Sea of Azov, an area of 190,000 square miles: it was at a remote period probably united with the Caspian Lake, their waters having covered all the steppe of Astrakhan. It receives some of the largest European rivers, and drains about 950,000 square miles, consequently its waters are brackish and freeze on its northern shores in winter. It is very deep, no bottom having been reached in some places at 960 feet; on the melting of the snow, such a body of water is poured into it by the great European rivers as to produce a rapid current, which sets along the western shore from the mouth of the Dnieper to the Bosphorus. The Sea of Azov may almost be considered as the estuary of the Don, notwithstanding its considerable extent of nearly 2000 square miles. Its current is produced by the influx of that great river: its greatest depth is 40 feet, shoaling gradually, at the rate of about one foot per mile, from the centre to the coasts.

Of all the branches of the Atlantic that enter deeply into the centre of the continent, the Mediterranean is the largest and most important, covering with its dark-blue waters more than 760,000 square miles. Situate in a comparatively low latitude, exposed to the heat of the African deserts on the S., and sheltered on the N. by the high land of Southern Europe, the evaporation is great; on that account the water of the Mediterranean is salter than that of the ocean, and for the same reason the temperature at its surface is higher than that of the Atlantic in the same latitude[1]; it does not decrease so rapidly downwards as in tropical seas, and it becomes constant at depths of from 340 to 1000 fathoms, according to the situations.[2] Although its own river domain is only 250,000 square miles, the constant current that sets in through the Dardanelles brings a great part of the drainage of the Black Sea, so that it is really fed by the melted snow and rivers from the Caucasus, the mountains of Asia Minor and Abyssinia, the Atlas, and the Alps. The quantity of water that flows into the Mediterranean from the Atlantic, by the superficial current in the Strait of Gibraltar, escapes by evaporation.

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[1] Mean temperature of the Mediterranean, 67°·3.
" " " Atlantic in same lat., 67°·1.

[2] It may be regarded as a general rule that the temperature of all inland seas, at great depths, represents nearly the mean temperature of the earth in the latitudes where they are situated; whilst, in the ocean, the low temperature at the bottom in every latitude is produced by the cold currents setting eternally from the polar regions, and which maintain the water at an almost constant temperature, probably 30° Fahrenheit, but not yet accurately ascertained.

The surface of the Mediterranean has the same level with the Red Sea,[1] and there was therefore no insuperable difficulty in cutting a ship canal from Lake Menzaleh to the Red Sea at Suez. In making his survey of the Mediterranean, Captain Spratt, R.N., came to the conclusion that no permanent port could be formed in the bay of the Mediterranean into which the canal opens, because it is so continuously and regularly silted up that no dredging could contend against a great local law of nature. Besides, the blown sand drifted from the W. would constantly be filling up the canal; and the incoherent nature of the ground in which the canal is cut, which is merely ancient drifted sand, would not sustain a steady body of water, so that all attempts to clear out its unceasing infillings of matter would be impracticable. Hence it remains to be seen whether this important enterprise will fail on account of the expense of maintaining it. At present (1869) it appears to be successful.

The Mediterranean is divided into two basins by a shallow plateau that runs from Cape Bon on the African coast to the southern and western coasts of Sicily, the depth varying from seven to 240 fathoms. On each side of this ridge the water is exceedingly deep. In the Strait of Gibraltar the greatest depth does not exceed 450 fathoms; but E. of this the depth increases considerably in some places—between Algiers and Toulon to 1600 fathoms. The soundings lately executed for laying down the submarine telegraph cable between Sardinia and the coast of Africa have given still greater depths. E. of the meridian of Malta commences the second deep basin, which extends uninterruptedly to the coast of Syria, in the midst of which rises abruptly the island of Candia. From the soundings executed by two of our most distinguished naval surveyors, Captains Maunsell and Spratt, the greatest depth between the 17th and 19th meridians E. of Greenwich is 2170; and on a line between Alexandria and Rhodes, 1600 fathoms. At Nice, within a few yards of the shore, it is nearly 700 fathoms deep. This sea is not absolutely without tides; in the Adriatic they rise five feet in the port of Venice, at the great Syrtis five feet at new and full moon, at Naples about 12 inches, but in most other places they are scarcely perceptible. The surface is traversed by various currents, two of which, opposing one another, occasion the celebrated whirlpool of Charybdis, whose terrors were much diminished by the earthquake of 1783. Its bed is subject to violent volcanic paroxysms, and its surface is studded with islands of all sizes, from the magnificent kingdom of Sicily to mere barren rocks—some actively volcanic, others of volcanic formation, and many of the secondary geological period.

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[1] The surveys executed for the maritime canal between the Mediterranean and Suez showed that the difference of level between the two seas, if any, is very trifling.

Various parts of its coasts are in a state of great instability; in some places they have sunk down and risen again more than once within the historical period; but these are produced by local causes, and are not general.

In the Caribbean Sea and the Mexican Gulf the temperature is about 83°·5 of Fahrenheit, while the Atlantic Ocean in the same latitude is not above 77° or 79°. Of that huge mass of water, partially separated from the Atlantic by a long line of islands and banks, the Caribbean Sea is the largest; it is as long from E. to W. as the distance between Great Britain and Newfoundland, and occupies a million of square miles. Its depth in many places is very great, and its water is limpid. The Gulf of Mexico, fed by the Mississippi, one of the greatest of rivers, is more than half its size, or about 800,000 square miles, so that the whole forms a sea of great magnitude. Its shores, and the shores of the numerous islands, are dangerous from shoals and coral-reefs, but the interior of these seas is not. The trade-winds prevail there; they are subject to severe northern gales, and some parts are occasionally visited by tremendous hurricanes.

The accurate surveys undertaken for the railroad across the isthmus have shown that there is no other difference of level between the Atlantic and Pacific than that depending on the different times of high and low water, produced by the tides on the eastern and western shores.

As the Pacific does not penetrate the land in the same manner that the Atlantic does the continent of Europe, there are fewer great gulfs, or internal seas. Of the latter, the Sea of Okhotsk is the most extensive.

The Red Sea and the Persian Gulf are joined to the Indian Ocean by very narrow straits. The physical geography of the Red Sea is better known, and is of more importance since it has become the most direct highway to our eastern possessions. Separating Africa from Arabia, it extends in a north-easterly direction for 1230 miles from the Strait of Bab-el-Mandeb to the Isthmus of Suez. Its greatest breadth is 192 miles, but it is only 72 miles across where the peninsula of Sinai causes it to bifurcate into two elongated gulfs. The Gulf of Suez is 167 miles long, its greatest breadth is 30, but at its mouth it is only 17 from shore to shore. On an average it is only 22 fathoms deep, but in some places it is as much as 50 fathoms.

The Gulf of Akabá is not so large, being 100 miles long and 16 across. It is much deeper, no bottom having been found with a line of 200 fathoms in some places; its general depth is 120.

The greatest ascertained depth of the Red Sea is 400 fathoms without bottom, in lat. 25° 20′ N., but there seems to be a submarine gulf from 5 to 10 miles wide, with abrupt and precipitous sides, which runs down the centre of the sea, in which the water is from 150 to 250 fathoms deep. A reef runs across the sea from Mocho in 13° 30′ N. lat. to the African coast, over which the depth varies from 25 to 30 fathoms, but in mid-channel it reaches 40.

The Strait of Bab-el-Mandeb is divided by the island of Perim, which has an excellent roadstead, where a fleet might lie in safety under shelter of volcanic cliffs. The wider channel is 13 miles across, with a depth of 100 fathoms in the middle. The ships from Aden prefer the lesser, which is only a mile and three quarters broad, but in mid-channel there are 30 fathoms water with a sandy bottom up to both shores, so it may be passed at all times of the tide. The Gulf of Aden is a funnel-shaped estuary 900 miles long and nearly 200 across from the N.W. point of Africa to the Arabian shore; the central channel deep, shoaling to the shores, along which the water is shallow.

In the Red Sea almost no rain falls, no fresh water enters it; hence, by excessive evaporation in that dry region and low latitude, it would by this time have been evaporated and converted into one mass of solid salt, were it not that as fast as salt-water is brought in from the ocean by the upper currents it is carried out again by those beneath. Dr. Buist has computed that 165 cubic miles of water are annually dissipated in vapour from the Red Sea, all of which is replaced by surface currents from the ocean, while the brine resulting from this excessive evaporation, by its specific gravity, sinks to the bottom and flows out as an under-current; this exchange is so constant and so great that Dr. Buist thinks it more than probable that the Red Sea changes the entire amount of its waters at least once a year.

It is an invariable law when seas of different densities are connected that an exchange of water must take place, a salt and dense under-current, and a less salt and consequently lighter surface current, flowing in an opposite direction.

The summer monsoon is S.E. in the region of the Red Sea, thus blowing down its axis for four months, while during the rest of the year the wind is from the N.W. The water of this sea is extremely pure and transparent, of an intense blue, changing to greenish-blue, bluish-green, and green, according as the coral, which is mostly white, lies near the surface.

The Red Sea and Arabian Gulf are covered with large patches, varying in size from a few yards to some square miles, of an intensely blood-red colour, derived from animalcula, which are particularly abundant in spring.[1]

Almost all the internal seas on the eastern coasts of Asia, except the Yellow Sea, are great gulfs shut in by islands, like the Caribbean Sea and the Gulf of Mexico, such as the China Sea, the seas of Japan and of Okhotsk.

The set of the great oceanic currents has scooped out and indented the southern and eastern coasts of the Asiatic continent into enormous bays and gulfs, and has separated large portions of the land, which now remain as islands—a process which probably has been increased by the submarine fires extending along the eastern coast from the equator nearly to the Arctic Circle.

The perpetual agitation of the ocean by winds, tides, and currents is continually, but slowly, changing the form and position of the land—steadily producing these vicissitudes on the surface of the earth to which it has always been subject, and to which it will assuredly be liable in all succeeding ages.

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[1] Dr. Buist, of Bombay, on the Physical Geography of the Red Sea, in Journal of Geographical Society of London.

CHAPTER XIX.

RIVERS.

§ 1. Origin of springs; variations in their temperature. § 2. Rise of rivers; their courses and velocity; tides and floods. § 3. Hydraulic systems of Europe; the Volga and Danube; the Rhine, Meuse, and Scheldt; the Spanish river system; British rivers. § 4. African rivers; Dr. Livingstone's explorations on the Zambezi; the Nile and the Niger, &c.

§ 1. The invisible vapour which rises from the land and water ascends in the atmosphere till it is condensed by the cold into clouds, which restore it again to the earth in the form of rain, hail, and snow; hence there is probably not a drop of water on the earth's surface that has not been borne on the wings of the wind. Part of this moisture restored to the earth is reabsorbed by the air, part supplies the wants of animal and vegetable life, a portion is carried off by the streams, and the remaining part penetrates through porous soils till it arrives at a stratum impervious to water, where it accumulates in subterranean lakes often of great extent. The mountains receive the greatest portion of the aërial moisture, and, from the many alternations of permeable and impermeable strata they contain, a complete system of reservoirs is formed in them, which, continually overflowing, form perennial springs at different elevations, which uniting and running down their sides form the sources of rivers. A great portion of the water at these high levels penetrates the earth till it comes to an impermeable stratum below the plains, where it collects in sheets, or nappes, and is forced by hydraulic pressure to rise in springs, through openings in the ground, to the surface. In this manner the water which falls on hills and mountains is carried through highly inclined strata to great depths, and even below the bed of the ocean, in many parts of which there exist, from this cause, springs of fresh water. In boring Artesian wells the water often rushes up with such impetuosity by the hydrostatic pressure as to form jets 40 or 50 feet high. In this operation several successive reservoirs have been met with: at St. Ouen, near Paris, five sheets of water were found; that in the first four not being good, the operation was continued to a greater depth; it consists merely in boring a hole of small diameter, and lining it with a metallic tube. It rarely happens that water may not be procured in this way; and as the substratum in many parts of deserts is an argillaceous marl, it is probable that Artesian wells might be bored with success in the most arid regions. This has of late years been verified to great advantage in Algeria, where Artesian wells have brought fertility to districts hitherto arid and uncultivated.

A spring will be intermittent when it issues from an opening in the side of a reservoir fed from above, if the supply be not equal to the waste, for the water will sink below the opening, and the spring will stop till the reservoir is replenished. Few springs give the same quantity of water at all times, those near the surface depending for their supply on the water that percolates the surface; they also vary much in the quantity of foreign matter they contain. Mountain-springs are generally very pure; the carbonic acid gas almost always found in them escapes into the atmosphere, and their earthy matter is deposited as they run along; so that river-water from such sources is soft, while wells and springs in the plains are hard, and more or less mineral.

Springs acquire their temperature from that of the strata through which they pass; mountain-springs are cold, but, if the water has penetrated deep into the earth, it acquires a temperature depending on that circumstance.

The temperature of the surface of the earth varies with the seasons to a certain depth, where it becomes permanent and for the most part equal to the mean annual temperature of the air above. It is evident that the depth at which this stratum of invariable temperature lies must vary with the latitude. At the equator the effect of the seasons is imperceptible at the depth of a foot below the surface: between the parallels of 40° and 52° the temperature of the ground in Europe is constant at the depth of from 55 to 60 feet: and in the high Arctic regions the soil is perpetually frozen a foot below the surface. Now, in every part of the world where experiments have been made, the temperature of the earth increases with the depth below the constant stratum at the rate of 1° of Fahrenheit for every 50 or 60 feet of perpendicular depth; hence, should the increase continue to follow the same ratio, even granite must be in fusion at little more than five miles below the surface. In Siberia the stratum of frozen earth is some hundred feet thick, but below that the increase of heat with the depth is three times as rapid as in Europe. The temperature of springs must therefore depend on the depth to which the water has penetrated before it has been forced to the surface, either by the hydrostatic pressure of water at higher levels or by steam. If it never descends below the stratum of invariable temperature, the heat of the source will vary with the seasons, more or less, according to the depth below the surface; should the water come from the constant stratum itself, its temperature will be invariable; and if from below it, the heat will be increased in proportion to the depth to which it has penetrated. Thus, there may be hot and even boiling springs hundreds of miles distant from volcanic action and volcanic strata, of which there are many examples, though they are more frequent in volcanic countries and those subject to earthquakes. The temperature of hot springs is very constant, and that of boiling springs has remained unchanged for ages: shocks of earthquakes sometimes affect their temperature, and have even stopped them altogether. Jets of steam of high tension are frequent in volcanic countries, as in Iceland.

Water both hot and cold dissolves and combines with many of the mineral substances it meets with in the earth, and comes to the surface from great depths as medicinal springs, containing various chemical ingredients. So numerous are they that in the Austrian dominions alone there are 1500; and few countries of any extent are destitute of them. They contain hydro-sulphuric and carbonic acids, sulphur, iron, magnesia, and other substances. Boiling springs deposit silex, as in Iceland and in the Azores; and others of lower temperature deposit carbonate of lime in great quantities all over the world. Springs of pure brine are rare; those in Cheshire are rich in salt, and have flowed unchanged 1000 years, a proof of the tranquil state of that part of the globe. Many substances that lie beyond our reach are brought to the surface by springs, such as naphtha, petroleum, and boracic acid; petroleum is abundant in Persia: numberless springs and lakes of it surround some parts of the Caspian Sea, and the oil-springs of Pennsylvania yield more than 1,000,000 barrels of crude oil per annum. Boracic acid, originally a gaseous emanation, is almost peculiar to Tuscany; it is found also in the Western Himalaya, and in combination with soda in some parts of Tibet.

RIVERS.

§ 2. Rivers have had a greater influence on the location and fortunes of the human race than almost any other physical cause, and, since their velocity has been overcome by steam-navigation, they have become the highway of nations.

They frequently rise in lakes, which they unite with the sea; in other instances they spring from small elevations in the plains, from perennial sources in the mountains, alpine lakes, melted snow and glaciers; but the everlasting storehouses of the mightiest floods are the ice-clad mountains of table-lands.

Rivers are constantly increased, in descending the mountains and traversing the plains, by tributaries, till at last they flow into the ocean, their ultimate destination and remote origin. "All rivers run into the sea, yet the sea is not full," because it gives in evaporation an equivalent for what it receives.

The Atlantic, the Arctic, and the Pacific Oceans are directly or indirectly the recipients of all the rivers; therefore their basins are bounded by the principal watersheds of the continents; for the basin of a sea or ocean does not mean only the bed actually occupied by the water, but comprehends also all the land drained by the rivers which fall into it, and is bounded by an imaginary line passing through all their sources. These lines generally run through the elevated parts of a country that divide the streams which flow in one direction from those that flow in another. But the watershed does not coincide in all cases with mountain-crests of great elevation, as the mere convexity of a plain is often sufficient to throw the streams into different directions.

From the peculiar structure of the highlands and mountain-chains, by far the greater number of important rivers on the globe flow into the ocean in an easterly direction, those which flow to the S. and N. being the next in size, while those that flow in a westerly direction are comparatively small and unimportant.

The course of all rivers is changed when they pass from one geological formation to another, or by dislocations of the strata: the sudden deviations in their directions are generally owing to the latter circumstance.

None of the European rivers flowing directly into the Atlantic exceed the fourth or fifth magnitude, except the Rhine; the rest of the principal streams reach it indirectly through the Baltic, the Black Sea, and the Mediterranean. It nevertheless receives nearly half the waters of the old continent, and almost all of the new, because the Andes and Rocky Mountains, which form the watershed of the American continent, lie along its western side, and the rivers which rise on their western slopes flow to the E., whilst those of the Alleghanies are tributaries to the Mississippi, which comes indirectly into the Atlantic by the Gulf of Mexico.

The Arctic Ocean drains the high northern latitudes of America, and receives those great Siberian rivers that originate in the Altaï range from the Steppe of the Kirghiz to the extremity of Kamtchatka, as well as the very inferior streams of North European Russia. The running waters of the rest of the world flow into the Pacific. The Caspian and Lake Aral are mere salt-water lakes, which receive rivers, but emit none. However, nearly one-half of all the running water in Europe falls into the Black Sea and the Caspian.

Mountain torrents gradually lose velocity in their descent to the low lands by friction, and when they enter the plains their course becomes still more gentle and their depth greater. A slope of one foot in 200 prevents a river from being navigable, and a greater inclination forms a rapid or cataract. The speed, however, does not depend entirely upon the slope, but also upon the height of the source of the river, and the pressure of the body of water in the upper part of its course; consequently, under the same circumstances, large rivers run faster than small, but in each individual stream, the velocity is perpetually varying with the form of the banks, the winding of the course, and the changes in the width of the channel. The Rhone, one of the most rapid European rivers, has a declivity of one foot in 2624, and flows at the rate of 120 feet in a minute; the sluggish rivers in Flanders have only one-half that velocity. Tht Danube, the Tigris, and the Indus are among the most rapid of the large rivers. In flat countries rivers are generally more meandering, and thus they afford a greater amount of irrigation; the windings of the Vistula are nearly equal to nine-tenths of its direct course from its source to its mouth.

When one river falls into another, the depth and velocity are increased, but not always proportionally to the width of the channel, which sometimes even becomes less, as at the junction of the Ohio with the Mississippi. When the angle of junction is very obtuse, and the velocity of the tributary stream great, it sometimes forces the water of its primary to recede a short distance. The Arve, swollen by a freshet, occasionally drives the water of the Rhone back into the Lake of Geneva; and it once happened that the force was so great as to make the mill-wheels revolve in a contrary direction.

Streams sometimes suddenly disappear, and after flowing underground to some distance reappear at the surface, as in Derbyshire. Instances have occurred of rivers suddenly stopping in their course for some hours, and leaving their channels dry. On the 26th of November, 1838, the water failed so completely in the Clyde, Nith, and Teviot, that the mills were stopped eight hours in the lower part of their streams. The cause was the coincidence of a gale of wind and a strong frost, which congealed the water near their sources. Exactly the contrary happens in the Siberian rivers which flow from S. to N. over so many hundreds of miles; the upper parts are thawed, while the lower are still frozen, and the water, not finding an outlet, inundates the country.

The alluvial soil carried down by streams is gradually deposited as their velocity diminishes; and if they are subject to inundations, and the coast flat, it forms deltas at their mouths; there they generally divide into branches, which often join again, or are united by transverse channels, so that a labyrinth of streams and islands is formed. Deltas are sometimes found in the interior of the continents at the junction of rivers, exactly similar to those in the ocean, though less extensive: deltas are said to be maritime, lacustrine, or fluviatile, according as the stream that forms them falls into the sea, a lake, or another river.

Tides flow up some rivers to a great distance, and to a height above that of their level in the sea: the tide is perceptible in the river Amazon 576 miles from its mouth, and it ascends 255 miles in the Orinoco.

In the temperate zones rivers are subject to floods from autumnal rains, and the melting of the snow, especially on mountain-ranges. The Po, for example, spreads desolation far and wide over the plains of Lombardy; but these torrents are as variable in their recurrence and extent as the climate which produces them. The inundations of the rivers in the torrid zone, on the contrary, occur with a regularity peculiar to a region in which meteoric phenomena are uniform in all their changes. These floods are due to the periodical rains, which, in tropical countries, follow the cessation of the trade-winds after the vernal equinox and at the turn of the monsoons, and are thus dependent on the declination of the sun, the immediate cause of all these variations. The melting of the snow no doubt adds greatly to the floods of the tropical rivers which rise in high mountain-chains, but it is only an accessory circumstance; for although the snow-water from the Himalaya swells the streams considerably before the rains begin, yet the principal effect is owing to the latter, as the southern face of the Himalaya is not beyond the influence of the monsoon, and the consequent periodical rains, which besides prevail all over the plains of India traversed by the great rivers and their tributaries.

Under like circumstances, the floods of rivers whose sources are in the same latitude take place at the same season; but the periods of the inundations of rivers on one side of the equator are exactly the contrary of what they are in rivers on the other side of it, on account of the declination of the sun. The flood in the Orinoco is at its greatest height in the month of August, while that of the river Amazon, S. of the equinoctial line, is at its greatest elevation in May. The commencement and end of the annual inundations in each river depend upon the average time of the beginning, and on the duration of the rains in the latitudes traversed by its affluents. The periods of the floods in such rivers as run towards the equator are different from those flowing in an opposite direction; and as the rise requires time to travel, it happens at regular but different periods in various parts of the same river, if very long. The height to which the water rises in the annual floods depends upon the nature of the country, but it is wonderfully constant in each individual river where the course is long; for the inequality in the quantity of rain in a district drained by any of its affluents is imperceptible in the general flood, and thus the quantity of water carried down is a measure of the mean humidity of the whole country comprised in its basin from year to year. By the admirable arrangement of these periodical inundations, the fresh soil of the mountains, borne down by the water, enriches countries far remote from their source. The waters from the high lands on the northern border of the great plateau, and of Abyssinia, have fertilized the banks of the Nile through a distance of 2500 miles for thousands of years.

When rivers rise in mountains, water-communication between them in the upper parts of their course is impossible; but when they descend to the plains, or rise in the low lands, the boundaries between the countries drained by them become low, and the different systems may be united by canals. It sometimes happens in extensive and very level plains that the tributaries of the principal streams either unite or are connected by a natural canal by which a communication is formed between the two basins—a circumstance advantageous to the navigation and commerce of both, especially where the junction takes place far inland, as between the Orinoco and Amazon in the interior of South America. The Rio Negro, one of the largest affluents of the latter, is united to the Upper Orinoco in the plains of Esmeralda by the Cassiquiare—a stream as large as the Rhine, with a velocity of 12 feet in a second. Baron Humboldt observes that the Orinoco, sending a branch to the Amazon, is, with regard to distance, as if the Rhine should send one to the Seine or Loire. At some future period this junction will be of great importance. These bifurcations are frequent in the deltas of rivers, but very rare in the interior of continents.

§ 3. The hydraulic system of Europe is eminently favourable to inland navigation, small as the rivers are in comparison with those of other parts of the world; but the flatness of the great plain, and the lowness of its watershed, are very favourable to the construction of canals. In the west, however, the Alps and German mountains divide the waters that flow to the Atlantic on one side, and to the Mediterranean and Black Sea on the other; but in the eastern parts of Europe the division of the waters is merely a more elevated ridge of the plain itself, for in all plains such undulations exist, though often imperceptible to the eye. This watershed begins on the northern declivity of the Carpathian Mountains about the 23rd meridian, in a low range of hills running between the sources of the Dnieper and the tributaries of the Vistula, from whence it winds in a tortuous course along the plain to the Valdai table-land, which is its highest point, 1200 feet above the sea; it then declines northward towards Onega, about the 60th parallel, and lastly turns in a very serpentine line to the sources of the Kama in the Ural mountains near the 62nd degree of N. latitude. The waters N. of this line run into the Baltic and White Sea, and, on the S. of it, into the Black Sea and the Caspian.

Thus Europe is divided into two principal hydraulic systems; but since the basin of a river comprehends all the plains and valleys drained by it and its tributaries from its source to the sea, each country is subdivided into as many natural divisions or basins as it has primary rivers, and these generally comprise all the rich and habitable parts of the earth, and are the principal centres of civilization, or are capable of becoming so.

The streams to the N. of the general watershed are very numerous; those to the S. are of greater magnitude. The systems of the Volga and Danube are the most extensive in Europe; the former has a basin comprising 397,460 square miles, and is navigable throughout the greater part of its course. It rises in a small lake on the slopes of the Valdai table-land, 550 feet above the level of the ocean, and falls into the Caspian, which is 83 feet 7 inches below the level of the Black Sea, so that it has a fall of 633 feet in a course of more than 2400 miles. It carries to the Caspian one-seventh of all the river-water of Europe.

The Danube drains 234,080 square miles, and receives 60 navigable tributaries. Its quantity of water is nearly as great as that of all the rivers that empty themselves into the Black Sea taken together. Its direct course is 880 miles, its meandering line is 1496.[1] It rises in the Black Forest at an elevation of 2850 feet above the level of the sea, so that it has considerable velocity, which, as well as rocks and rapids, impedes its navigation in many places, but it is navigable downwards, through Austria, for 600 miles, to New Orsova, from whence it flows in a gentle current to the Black Sea. The commercial importance of these two rivers is much increased by their flowing into inland seas. By canals between the Volga and the rivers N. of the watershed, the Baltic and White Seas are connected with the Black Sea and the Caspian; and the Baltic and Black Sea are also connected by a canal between the Don and the Dnieper. Altogether, the water-system of Russia is the most extensive in Europe.

The whole of Holland is a collection of deltoid islands, formed by the Rhine, the Meuse, and the Scheldt—a structure very favourable to commerce, and which has facilitated an extensive internal navigation. The Mediterranean is already connected with the North

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[1] Mr. Keith Johnston's Phys. Atlas.

Sea by the canal which runs from the Rhone to the Rhine; and this noble system, extended over the whole of France by 7591 miles of inland navigation, has conduced much to the prosperous state of that great country.

Many navigable streams rise in the Spanish mountains; of these the Tagus has depth enough for the largest ships as high as Lisbon. Its actual course is 480 miles, but its direct one much less. In point of magnitude, however, the Spanish rivers are of inferior order, but canals have rendered them beneficial to the country. Italy is less favoured in her rivers, which only admit vessels of small burthen; those on the N. are by much the most important, especially the Po and its tributaries, which by canals connect Venice and Milan with various fertile provinces of Northern Italy; but whatever advantages nature has afforded to the Italian states have been improved by able engineers, both in ancient and modern times.

The application of the science of hydraulics to rivers took its rise in Northern Italy, where it has been carried to such perfection in some points that China is the only country which can vie with it in the practice of irrigation. The lock on canals was in use in Lombardy as early as the 13th century, and in the end of the 15th it was applied to two canals which unite the Ticino and the Adda, by that great artist and philosopher Leonardo da Vinci; about the same time he introduced the use of the lock into France.[1]

Various circumstances combine to make the British rivers more useful than many others of greater magnitude. The larger streams are not encumbered with rocks or rapids; they all run into branches of the Atlantic; the tides flow up their channels to a considerable distance; and above all, though short in their course, they end in wide estuaries and sounds, capable of containing whole navies—a circumstance that gives an importance to streams otherwise insignificant when compared with the great rivers of either the old or new continent.

The Thames, whose basin is only 5027 square miles, and whose length is but 240, of which, however, 204 are navigable, spreads its influence over the remotest parts of the earth; its depth is sufficient to admit large vessels even up to London, and throughout its navigable course a continued forest of masts displays the flags of every nation: on its banks, which are in a highly cultivated state, is the seat of the highest civilization, moral and political. Local circumstances have undoubtedly been favourable to this superior development, but the earnest and energetic temperament of the Saxon races has rendered these natural advantages of position much more available. The same may be said of other rivers in the British islands, where commercial enterprise and activity vie with those on the Thames. There are 2790 miles of navigable canals in Britain, and, including rivers, 5430 miles of inland navigation, which, in comparison with the area of the country, is very great; it is even said that no part of England is more than 15 miles distant from water-communication.

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[1] Leonardo da Vinci was appointed Director of Hydraulic Operations in Lombardy by the Duke of Milan, and during the time he was painting the "Last Supper" he completed the Martesana Canal, extending from the Adda to Milan, and improved the course of the latter river from where it emerges from the Lake of Como to the Po. By means of the Naviglio Grande, the Martesana Canal establishes a water-communication between the Adda and the Ticino, the Lakes of Como and Maggiore.

On the whole, Europe is fortunate with regard to its water-systems, and its inhabitants are for the most part alive to the bounties which Providence in this respect has bestowed upon them.

AFRICAN RIVERS.

§ 4. In Africa the tropical climate and the extremes of aridity and moisture give a totally different character to its rivers. The most southerly part is comparatively destitute of them, and those that do exist are of inferior size, except the Gariep, or Orange River, which has a long course on the table-land, but is nowhere navigable. In comparatively level tracts of no great elevation in the centre of the table-land, rise those innumerable streams which fill the plateau of South Africa with a perfect maze of large rivers, of which the Zambesi or Leambye is the main artery. That river is now known to be one of the greatest of the continent. It drains an area extending over 10 degrees of latitude, and nearly 32 of longitude. It takes its rise in the Gilolo hills, and is joined by the Leeba at the northern extremity of the Barotse valley, about 800 miles from Loanda. It then flows from N. to S. for 240 miles, where it is joined by the noble deep river Chobe, in 18° 17′ S. lat. and 23° 50′ E. long. The first hundred miles is through the Barotse valley, a grazing country, with the towns raised on mounds on account of the annual inundations. After this the river is extremely beautiful, and often a mile broad, with many islands covered with the richest vegetation. Before its junction with the Chobe, its bed becomes rocky as well as its banks, which are undulating, and the trees send down roots from their branches like the banyan. The united stream flows to the E., and in 17° 57′ S. lat. and 26° 6′ E. long. forms one of the most magnificent cataracts known. The river, here 1000 yards broad, drops into a deep narrow chasm in the basaltic rock, not more than 25 yards wide, and 300 feet deep, finding an outlet near one extremity of the cleft, and pursuing its rapid course through a succession of similar ravines lower down.

The effect of its sudden contraction and fall is in the highest degree sublime, and, from the point from which Dr. Livingstone saw it, appalling, for he got a native of sufficient nerve to paddle a canoe to an islet immediately above the fall: the columns of vapour rushing up for 300 or 400 feet form dense clouds, whence the name of "Mosioatunya," or the "smoke-resounding falls." When Dr. Livingstone saw this fall, the waters were low, but during the inundations, when the river flows between banks many miles wide, and still forces itself through the same narrow space, it must be terrifically magnificent beyond description; at these times the columns of spray may be seen, and the roar heard, 10 or 12 miles off.

After entering this chasm, the river changes its course, foams and rages through a narrow channel amongst tree-covered hills, and then, emerging from its confines, it spreads out again, and flows to the N.N.E., in a broad placid stream, to its junction with the Kafue, a large fine river, coming from the W.; from that the combined stream runs in a bending line eastward to its confluence with the Mutu or Quilimane, at the head of its delta, where it is three-quarters of a mile broad. There is a great body of water in it during the rains, and in the dry season it is shallow, except in its winding mid-channel. Its delta is 300 miles long, and as large as Scotland. It would be vain to mention all the rivers that flow into the Zambesi, they are so numerous and complicated; but the Shiré is too important to be omitted. It rises in Lake Nyassa, and in the middle of its course of 200 miles, from so high an altitude to the Zambesi, forms a series of cataracts 40 miles long.

The river next in importance on the East African coast is the Limpopo, a large stream, whose upper waters, flowing over the table-lands of the interior, have long been well known to elephant hunters, and form the western and northern frontiers of the Trans-Vaal Republic. Lower down its course has hitherto been an enigma to geographers, and no less than five different embouchures in the Indian Ocean have been assigned to it, extending over four degrees of latitude. Various obstacles have prevented the exploration of this portion of the river, amongst which is the prevalence of the tsetse fly in the low lands, beyond the point where the river breaks through the ridges which limit the table-land of the interior. In 1869, however, Mr. St. Vincent Erskine boldly undertook to solve the problem. He marched on foot from Leydenburg to the junction of the Lipaluli (a large southern affluent) and the Limpopo, which he found to be in 23° 34′ S. lat. and 33° 40′ E. long., and then descended by the left bank of the main stream, finding its mouth, after a hazardous and toilsome journey, to be the same as that of the river Inhampura of modern maps, a little to the N. of Delagoa

Bay. The shallowness of the water in the lower part, and the formidable sandbanks across the mouth of the river will unfortunately prevent this fine river, which has a course of nearly 900 miles through a varied and productive region, from ever becoming useful as a channel of communication.

The rivers which flow to the Atlantic, and fertilize the luxuriant maritime plains of Benguela, Congo, Angola, and Loango, have their sources on the table-land. The Casai, far in the interior, being joined by the Casango, runs N. through a country of forests alternating with sward, and then turning to the W. rushes through a cleft in the limiting ridge of the table-land, and descends to the plains as the Congo, which like most of the African rivers is navigable for only a short distance above its mouth (160 miles), where the ascending tide is stopped by cataracts. In its lower course this river is five or six miles broad, studded with islands, and very deep at its mouth. On account of the abrupt descent from the high country to the maritime plains, none of these rivers afford access to the interior of South Africa.

Farther to the N. the Ogowai, a noble river, probably not inferior to the Congo or Zambesi, is formed by the junction of two great streams, the Okanda, probably the main stream, coming from the unknown region to the N.E., and the Ngunyai, discovered by the adventurous explorer Du Chaillu, coming from the S.E. The Ogowai and Okanda are navigable in the rainy season as far as they have been explored, and their waters at the mouth form a common delta with the Fernand Vaz. The Nazareth and Mexias, hitherto believed to be separate rivers, are merely two of the mouths of this system of rivers. Dr. Barth suspected the Ogowai to be the lower part of that river which was described to him as running westward many days' journey S. from Wadai, and he believed there was a vast field for future discovery along the great Okanda branch of the Ogowai.

The mountainous edge of the table-land, with its terminal projections, Senegambia and Abyssinia, are the principal sources of the great streams of Central Africa. Various rivers have their origin in these elevated regions, of which the Nile and the Niger yield in size only to some of the great Asiatic and American rivers. In importance and historical interest the Nile is inferior to none.

Two large rivers unite their streams to form the Nile—the Bahr-el-Abiad, or White River, and the Bahr-el-Azrek, or Blue River; but the latter is so far inferior to the Bahr-el-Abiad that it is now regarded as a tributary. Another great tributary, of which little was known until it was visited by Petherick, is the Bahr-el-Gazal, which coming from a large level region to the W. and S. joins the White Nile in about 9° 30′ S. lat. The main stream has never been navigated by any traveller above 4° 9′ N. latitude, the point reached by the missionary Knoblecher, who could see the river for 30 miles farther coming from the S.W. The source of the White or true Nile is still unknown; Lake Victoria Nyanza, discovered by Captain Speke, being now considered merely the source of a large tributary, which, descending from a much higher level than the valley of the main stream, forms one of the feeders of the Albert Nyanza. Emerging from the northern extremity of the latter lake, the Nile pierces the barrier formed by a range of hills N. of Gondokoro, and is obstructed by numerous cataracts and rapids. These passed, it becomes a fine navigable stream for nearly a thousand miles to the cataracts of Nubia.

The Abyssinian tributary of the Nile, known as the Bahr-el-Azrek, or Blue River, rises under the name of the Didhesa in the Galla country, S. of Abyssinia, about 73 miles west of Saka, the capital of Enarea. It springs from a swampy meadow in the same elevated plains where the Godjeb and other affluents of the White Nile originate; it separates the kingdoms of Guma and Enarea, and maintains a general north-westerly direction till it joins the White Nile at Khartum. Of the many tributaries to the Blue River, the Abâi, the Nile of Bruce, is the largest and most celebrated. Its sources are in a swampy plain near Mount Giesh, in the district of Sákkata, from whence it takes a circular direction round the peninsula of Gojam, passing through Lake Dembea, and receiving many affluents from the mountain-chain that forms the centre of the peninsula, and at last falls into the Didhesa or Bahr-el-Azrek, in about 11° N. latitude. The Atbara, formed by the junction of the Gwang and Takkazé, is one of the principal tributaries of the Nile. The Takkazé rises in the mountains of Lasta, a day's journey from Lalíbala, one of the most celebrated places in Abyssinia, remarkable for its churches hewn out of the solid rock, and the Tselari, which springs from Mount Biála, the northern extremity of the high land of Lasta, which divides the head-waters of the two branches. The united stream, after winding like the other rivers of this country, joins the Nile in 18° N. latitude, the northern limit of the tropical rains.

The Abyssinian rivers in the upper part of their course are little more than muddy brooks in the dry season, but during the rains they inundate the plains. They have scooped in the table-lands deep ravines in the rocky surface; in emerging on the plains, they are at first only a few yards wide, but gradually increase to several miles; the streams form cataracts from 80 to more than 100 feet high, and then continue to descend by a succession of falls and rapids, which decrease in height as they run northwards to join the main stream. The Takkazé takes its name of "The

Terrible" from the impetuosity with which it rushes through the chasms and over the precipices of the mountains. The sediment brought down by this river, produced by attrition of the basaltic and other rocks, forms the fertilizing mud of Egypt. It is swept down during the rainy season. In the dry season the Atbara is merely a string of stagnant pools; it is to the White Nile solely that is due the perennial flow of water which prevents Egypt from becoming a barren waste of sand; and the irrigating stream is derived from the lake reservoirs under the equator.

From the Atbara down to the Mediterranean, a distance of 1200 miles, the Nile does not receive a single brook. The first part of that course is interrupted by cataracts, from the geological structure of the Nubian Desert, which consists of a succession of broad sterile terraces, separated by ranges of rocks running E. and W. Over these the Nile falls in nine or ten cataracts, the last of which is at Es-Souan (Syene), where it enters Egypt. Most of them are only rapids, where each successive fall of water is not a foot high. That they were higher at a former period has been rendered probable by Dr. Lepsius, a very intelligent traveller sent by the King of Prussia at the head of a mission to explore that country. He found a series of inscriptions on the rocks at Sennaar, marking the height of the Nile at different periods; from which it appears that in that country the bed of the river had been 30 feet higher than it is now.

Fifteen miles below Cairo, and at 90 miles from the sea, the Nile separates into two branches, one of which, running in a northerly direction, enters the Mediterranean below Rosetta; the other enters the sea above Damietta; the delta between these two places has a sea-coast of 187 miles. The fall from the great cataract to the sea is about two inches in a mile.

The full extent of the basin of the Nile is not at present known; if it embraces the whole of the equatorial lakes and their basins of drainage, as is now thought probable, it will form the most extraordinary river-system of the world. Excluding the southern lakes, it has an unusual form; it is wide in Ethiopia and Nubia, but for the greater part of a winding course of 2240 miles it is merely a verdant line of beauty, suddenly and strongly contrasted with the dreary waste of the Red Desert in the midst of which it lies. Extending from the equatorial far into the temperate zone, its aspect is less varied than might have been expected, on account of the parched and showerless country it passes through. Nevertheless, from the great elevation of the sources of the river, the upper portion has a perpetual spring, though within a few degrees of the equator. At the foot of the table-land of Abyssinia the country is covered with dense tropical jungles, while the rest of the valley, covered by the detritus of the mountains for thousands of years, is fertile and luxuriant.

As the mean velocity of the Nile, when not flooded, is about two miles and a half an hour, a particle of water would take 22½ days to descend from the junction of the Takkazé to the sea; hence the retardation of the annual inundations of the Nile in its course is a peculiarity of this river, owing to some unknown cause towards its origin which affects the whole stream. In Abyssinia and Sennaar the river begins to rise in April,[1] yet the flood is not perceptible at Cairo till towards the summer solstice; it then continues to rise during nearly a hundred days, and remains at its greatest height till the middle of October, when it begins to subside, and reaches its lowest point in April and May. The height of the flood in Upper Egypt varies from 30 to 35 feet; at Cairo it is 23, and in the northern part of the delta only four feet.

Anubis, or Sirius, the Dog-star, was held in veneration by the Egyptians, from its supposed influence on the rising of the Nile. According to Champollion, the calendar of that extraordinary people commenced when the heliacal rising of that star coincided with the summer solstice—the time at which the Nile began to rise at Cairo. Now this coincidence, according to the most accurate calculation, took place about 3291 years before the Christian era; and as the rising of the river occurs at precisely the same time and in the same manner, it follows that the heat and periodical rains in Upper Ethiopia have not varied for 5000 years. In the time of Hipparchus the summer solstice was in the sign of Leo, and probably about that period the flowing of the fountains from the mouths of lions of basalt and granite was adopted as emblematical of the pouring forth of the floods of the Nile. The emblem is still common among the Egyptian monuments transported to Rome. Since then the signs of the Zodiac have retrograded more than 30 degrees.

The two greatest African rivers, the Nile and the Niger, are dissimilar in almost every circumstance; the Nile, discharging its waters for ages into a sea the centre of commerce and civilization, has been renowned by the earliest historians, sacred and profane, for the exuberant fertility of its banks, and for the learning and wisdom of the people who inhabited them, and on which they have left magnificent and imperishable monuments of their genius and power. Egypt was for ages the seat of science, and by the Red Sea it had intercourse with the most highly cultivated nations of the East from time immemorial. The Niger, on the contrary, though its rival in magnitude, and running through a country glowing with all the brilliancy of tropical vegetation, has ever been inhabited by barbarous or semi-barbarous tribes; and its course till lately was little known, as its source still is. In early ages, before the Pillars of Hercules had been passed, and indeed long afterwards, the Atlantic coast of Africa was an unknown region, and thus the flowing of the Niger into that lonely ocean kept the natives in their original rude state. Such are the effects of local circumstances on the intellectual advancement of mankind.

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[1] The April rains in Abyssinia are slight, and coincide with the passage of the sun in the prime vertical, and a partial rise of the Nile corresponding to them has been observed at Cairo; but the principal rains, the probable cause of the great rise in the waters of the Nile, take place at a later period in Enarea, and probably throughout all Ethiopia between 7° and 9° N. It rains there every day in September; and as the maximum rise of the Nile at Cairo is in October, these two phenomena are evidently connected.—*D'Abbadie.*

The sources of the Niger, Joliba, or Quorra, are supposed to be on the northern side of the Kong Mountains, in the country of Bambarra, more than 1600 feet above the level of the sea. From thence it runs N., and, after passing through Lake Debo, makes a wide circuit in the plains of Soudan through eight or nine degrees of latitude; then bending round, it again approaches the Kong Mountains, at the distance of 1000 miles in a straight line from its source, and, having threaded them, it flows across the low lands into the Gulf of Guinea. In the plains of Soudan it receives many very large affluents from the high land of Senegambia on the W.; and the Tchadda, on the E., a navigable river larger than itself, falls into it a little below Fundah, after a course of some hundred miles: thus the Niger probably affords an uninterrupted water-communication from the Atlantic to the heart of Africa.[1] Long before emerging from the plains of Soudan, it becomes a noble river with a placid stream, running at the rate of from five to eight miles an hour, varying in breadth from one to eight miles. Its banks are studded with populous towns and villages, surrounded by groves of palm-trees and cultivated fields.

This great river divides into three branches near the head of a delta which is equal in area to Ireland, intersected by navigable branches of the principal stream in every direction. The soil consist of a rich mould, and the vegetation is so rank that the trees seem to grow out of the water. The Nun, which is the principal or central branch, flows into the sea near Cape Formosa, and is that by which the brothers Lander descended. There are, however, six rivers which run into the Bight of Benin, all communicating with the Niger, and with one another. The old Calabar is the most eastern; it rises in the high land of Calbongos, and is united to the Niger by a natural canal. The Niger, throughout its long winding course, lies entirely within the tropic of Cancer, and is consequently subject to periodical inundations, which reach their greatest height in August, about 40 or 50 days after the summer solstice. The plains of Soudan are then covered with water and crowded by boats. These fertile regions are inaccessible to Europeans from the pernicious climate, and from the savage nature of many of the tribes.

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[1] Captain W. Allen, R.N.

The coast of Guinea, W. of the Niger, is watered by many streams, of no great magnitude, descending from the Kong Mountains. From the table-land of Senegambia rise the Rio Grande, the Gambia, the Senegal, and others of great size, and also many of an inferior order that fertilize the maritime plains on the Atlantic. Their navigable course is cut short by a chain of mountains which forms the escarpment of the high land, through which they force their way in rapids and cataracts. The Gambia rises in Foula Toro, and after a course of about 600 miles enters the Atlantic by many branches connected by natural channels, supposed at one time to be separate rivers. The Senegal, the largest river in this part of Africa, is 850 miles long. It receives many tributaries in the upper part of its course, and the lower is full of islands. It drains two lakes, and is connected with the waters of the basin of the Gambia by the river Neriko.

CHAPTER XX.

ASIATIC RIVERS.

§ 1. Western Asiatic rivers; Euphrates and Tigris. § 2. Southern Asiatic rivers; the Indus, Ganges, and Brahmapootra; the Irrawady, Menam, and Cambodja. § 3. Chinese river-system; the Hong-Kiang, Yang-tse-Kiang, and Hoang-ho; the White River and the Amur. § 4. Siberian rivers; the Lena, Yenessei, and Oby.

§ 1. THE only river-system of importance in Western Asia is that of the Euphrates and Tigris, in the basin of which, containing an area of 230,000 square miles, immense mounds of earth, in a desolate plain, point out the sites of the most celebrated cities of antiquity—Nineveh and Babylon. Innumerable remains and inscriptions, the records of times very remote, have been discovered of late years, and bear testimony to the truth of some of the most interesting pages of sacred history. The Euphrates, and its affluent the Murad-Chaï (supposed to be the stream forded, as the Euphrates, by the Ten Thousand in their retreat), rise in the heart of Armenia, and, after running 1800 miles on the table-land to 38° 41′ of N. latitude, they join the northern branch of the Euphrates, which rises in the Gheul Mountains, near Erzeroum. The whole river then descends in rapids through the Taurus chain into the plains of Mesopotamia.

The Tigris rises in the mountains to the N. and W. of Diarbekr, and after receiving several tributaries from the highlands of Kurdistan, it pierces the Taurus range about 100 miles above Mosul, from whence it descends in a tortuous course through the plain of ancient Assyria, receiving many streams from the Tyari Mountains, inhabited by the Nestorian Christians, and, farther S., from those of Luristan. The country through which it flows is rich in cornfields, date-groves, and forest-trees. Near the city of Bagdad the Tigris and Euphrates approach to within 12 miles of each other, where they were once connected by two great canals. From this point they run nearly parallel for more than 100 miles, encircling the plain of Babylon or Southern Mesopotamia—the modern Irak-Arabi. The two rivers unite at Koorna, and form one stream, which, under the name of Shat el Arab, runs for 150 miles before it falls into the Persian Gulf. The banks of the Tigris and Euphrates, once the seat of an extensive population, and of art, civilization, and industry, are now nearly deserted, covered with brushwood and grass, dependent on the rains alone for that luxuriant vegetation which, under an admirable system of irrigation, formerly covered them. Excepting the two large centres of population, Bagdad and Mosul, the inhabitants consist of nomade Kurdish tribes. What remains of civilization has taken refuge in the mountains of the ancient Chaldeans, where the few traces of primitive and most ancient Christianity, under the misapplied denomination of Nestorian Christians, are to be found in the Tyari range. The floods of the rivers are very regular in their rise and fall; beginning in March, they attain their greatest height in June.

The Persian Gulf may be navigated by steam all the year, the Euphrates only eight months; it might, however, afford easy intercourse with Eastern Asia, as it did in former times. The distance from Aleppo to Bombay by the Euphrates is 2870 miles, of which 2700, from Bir to Bombay, are by water; in the time of our Queen Elizabeth this was the common route to India, and a fleet was then kept at Bir expressly for that navigation.

§ 2. Six rivers of the first magnitude descend from the southern side of the table-land of Eastern Asia and its mountain barriers, all different in origin, direction, and character, while they convey to the ocean a greater volume of water than all the rivers of the rest of the continent conjointly. Of these, the Indus, the double system of the Ganges and Brahmapootra, and the three parallel rivers of the Indo-Chinese peninsula, water the plains of Southern Asia; the great system of rivers that descend from the eastern terraces of the table-land irrigates the fertile lands of China; and lastly, the Siberian rivers, not inferior to any in magnitude, carry the waters of the Altaï and northern slope of the great Asiatic table-land to the Arctic Ocean.

The sources of the Indus were ascertained with tolerable accuracy in 1867, by natives trained in surveying and employed by Captain T. G. Montgomerie. They lie to the N. of Kailas Peak, and within a few miles of the sources of the Sutlej and the Brahmapootra, the dividing ridge between the Indus and the two other rivers lying parallel to the main chain of the Himalaya and a short transverse ridge parting the sources of the Sutlej and Brahmapootra. The direction of both the Indus and the Brahmapootra lies parallel to the axis of the Himalaya till they reach its known extremities, where they descend rapidly and turn abruptly through the Himalaya in their way to the plains of India. The main stream of the Indus is 750 miles long from its head, which is called the Lion River, about the 82nd eastern meridian, to Acho, in Lower Balti. It receives, in 79° 45′ E. long., the Gartung-chu River, at which point its waters flow at an elevation of 13,000 feet above the level of the sea. The gold district of Western Tibet, where several thousand people are continually employed in excavations at an elevation of 16,330 feet, lies a little to the E. of the mountain-ranges which enclose the river valley. Running N.W., it is joined, below Leh, by the Shyok, which flows from the southern slope of the Karakorum. At Acho, in Lower Balti, after a course of 200 miles, the Tibetan Indus descends W. of the valley of Cashmere to the plain of the Punjab. According to Captain Strachey, the Tibetan Indus drains 47,000 square miles. The greatest of its tributaries, the Sutlej, has two sources—one in the valley of Tsotso, and the other, known as the Elephant River, issues from the lake R'akas in the Gangri valley. These two streams, flowing in opposite directions, meet and break through the Himalaya about the 75th meridian, in one stream which traverses the whole breadth of the chain in frightful chasms to the plains of the Punjab. Three tributaries—the Jelum or Hydaspes, the Chenab or Acescines, and the Ravee or Hydraötes, all superior to the Rhone in size—flow from the southern face of the Himalaya, and with the Sutlej (the ancient Hyphasis) join the Indus before it reaches Mittun; hence the name Punjab, "the plain of the five rivers," now one of the most valuable countries of our Eastern empire. From Mittun to the ocean, the Indus, like the Nile, does not receive a single accessary, and from the same cause—the sterility of the country through which it passes. The Cabul River, which rises near Guzni, and is joined by a larger affluent from the southern declivities of the Hindoo Coosh, flows through picturesque and dangerous defiles, and joins the Indus at the town of Attock, and is the only tributary of any magnitude that enters it from the W.

The Indus is not well adapted for navigation: for 70 miles after it leaves the mountains the descent in a boat is dangerous, and it is only navigable for steam-vessels of small draught of water; yet, from the fertility of the Punjab, and the near approach of its basin to that of the Ganges at the foot of the mountains, it has already become a valuable acquisition, because it commands the principal roads between Persia and India, one through Cabul and Peshawur, and the other from Herat through Candahar. The delta of the Indus, formerly celebrated for its civilization, has long been a desert; but from the luxuriance of the soil, and the change of political circumstances, it may again resume its pristine aspect. It is 60 miles long, and presents a line of 120 miles along the sea in the Gulf of Oman, where the river empties itself by many mouths, of which only three or four are navigable; one only can be entered by vessels of 50 tons, and all are liable to change. The tide ascends them with extraordinary rapidity for 75 miles, and so great is the quantity of mud carried by it, and the absorbing violence of the eddies, that a vessel wrecked on the coast was buried in sand and mud in two tides. The annual floods begin with the melting of the snow in the Himalaya towards the end of April, attain their greatest height in July, and end in September. The length of the Indus is 1960 miles, and it probably drains an area of 312,000 square miles; but this is uncertain.

The second group of South Indian rivers, and one of the greatest, is the double system of the Ganges and Brahmapootra. These two rivers, though draining opposite sides of the main chain of the Himalaya, converge to a common delta, and constitute one of the most important river-systems on the globe.

Mr. Alexander Elliot, son of Admiral Elliot, and his friends, are the first who accomplished the arduous expedition to the sources of the Ganges. The river flows at once in a very rapid stream not less than 40 yards across, from a huge cave in a perpendicular wall of ice at a distance of about three marches from the Temple of Gungootree, to which the Hindoo pilgrims resort in great numbers. Mr. Elliot says, "The view from the glacier was perfectly amazing; beautiful or magnificent is no word for it—it was really quite astonishing. If you could fancy a bird's-eye view of all the mountains in the world in one cluster, and every one of them covered with snow, it would hardly give you an idea of the sight which presented itself."

Many streams from the southern face of the Himalaya unite at Hurdwar to form the great body of the river. It flows from thence in a south-easterly direction through the plains of Bengal, receiving in its course the tribute of 19 or 20 rivers, of which 12 are larger than the Rhine. About 220 miles in a direct line from the Bay of Bengal, into which the Ganges flows, the innumerable channels and branches into which it splits form an intricate maze over a delta twice as large as that of the Nile.

The Brahmapootra, a river superior in the volume of its waters to the Ganges, may be considered as the continuation of the Tsanpo or river of Lassa, which rises near the most eastern of the Sacred Lakes of Manasarowar, and, as already observed, not far from the sources of the Sutlej and Indus, in long. 82° E. After watering the great longitudinal valley in the highlands of Tibet, descending from an elevation above the sea-level of about 14,000 to 11,000 feet S. of Lassa, it makes a sudden bend to the S. in long. 90° E., cutting through the Himalaya chain, as the Indus does at its opposite extremity between Iskardo and Attock; after which it receives several tributaries from the northern mountains of the Birman empire; but very little is known of this part of its basin. The Tsan-po is parallel to the Himalaya chain, until it enters Upper Assam, where it is joined from the N.E. by the Brahmapootra, properly so called, which, having passed through the sacred pool of Brahma-Koond, receives the name which it bears in the lower part of its course—Brahmapootra, the "offspring of Brahma:" the natives call it the Lahit, Sanscrit for the "Red River." In Upper Assam, through which the united streams wind 500 miles, it forms some extensive channel islands, and receives six very considerable affluents, of which the origin is unknown, though some are supposed to come from the table-land of Eastern Tibet. They are only navigable in the plains, but vessels of considerable burthen ascend the parent stream as far as Sudiya. Before it enters the plains of Bengal, below Goyalpara, the Brahmapootra runs with rapidity and in great volume, and, after receiving the rivers of Bhotan and other streams, branches of it unite with those of the Ganges about 40 miles from the coast, but the two rivers enter the sea by different mouths, though they sometimes approach within two miles. The length of the Brahmapootra is estimated at 1680 miles, or nearly the same as that of the Ganges: the volume of water discharged by it during the dry season is about 146,188 cubic feet in a second; the quantity discharged by the Ganges in the same time and under the same circumstances is only 80,000 cubic feet. In the perennial floods the quantity of water poured through the tributaries of the Brahmapootra from their snowy sources is incredible; the plains of Upper Assam are an entire sheet of water from the 15th of June to the 15th of September, and there is no communication but by elevated causeways eight or ten feet high; the two rivers, with their branches, lay the plain of Bengal under water for hundreds of miles annually. They begin first to swell from the melting of the snow on the mountains, but, before their inferior streams overflow from that cause, all the lower parts of Bengal adjacent to the Ganges and Brahmapootra are under water from the swelling of these rivers by the rains. The increase is arrested, before the middle of August, by the cessation of the rains in the mountains, though they continue to fall longer on the plains. The delta is traversed in every direction by arms of the rivers. The Hoogly branch, at all times navigable, passes Calcutta and Chandernagor; and the Hauringotta arm is also navigable, as well as the Ganges properly so called. The channels, however, are perpetually changing, from the strength of the current and the prodigious quantity of matter brought down from the high lands. The Sunderbunds, a congeries of innumerable river-islands formed by the endless streams and narrow channels of the rivers, as well as by the indentations of arms of the sea, line the coast of

Bengal for 180 miles, a wilderness of jungle and forest. The united rivers of the Ganges and Brahmapootra drain an area of 432,480 square miles, and there is scarcely a spot in Bengal more than 20 miles distant from one of their tributary streams, navigable even in the dry season.

These three great rivers of Southern India do not differ more widely in their physical circumstances than in the races of men who inhabit their banks, yet from their position they seem formed to unite nations the most varied in their aspect and speech. The tributaries of the Ganges and Indus come so near to each other at the foot of the mountains that a canal only two miles long would unite them, and thus an inland navigation from the Bay of Bengal to the Gulf of Oman might be established.

An immense volume of water is poured in a series of nearly parallel rivers of great magnitude, and running in a meridional direction, through the Indo-Chinese peninsula, to empty themselves into the ocean on either side of the peninsula of Malacca. They rise in those elevated regions at the south-eastern angle of the table-land of Tibet, the lofty but unknown provinces of the Chinese empire, and water the great valleys that extend nearly from N. to S. with perfect uniformity, between chains of mountains no less uniform, which spread out like a fan as they approach the sea. Scarcely anything is known of the sources or upper parts of these rivers, and, with a few exceptions, little of the lower.

Their number amounts to six or seven, all large, though three surpass the rest in size—the Irrawady, which waters the Birman empire, and falls into the Bay of Bengal at the Gulf of Martaban; the Menam, or river of Siam; and the river Cambodja, which flows through the empire of Anam: the last two fall into the Gulf of Siam and the China Sea.

The sources of the Irrawady are in the same chain of mountains with the eastern affluents of the Brahmapootra. Its course is through countries hardly known to Europeans, but it appears that it is navigable by boats before reaching the city of Amarapoora, S. of which it enters the finest and richest plain of the empire, containing its four capital cities. There it receives two large affluents, one from the Chinese province of Yunnan, which flows into the Irrawady at the city of Ava, 446 miles from the sea, the highest point attained by the British forces during the Burmese war.

From Ava to its delta the Irrawady is a magnificent stream, more than four miles broad in some places, but encumbered with numerous islands. In this part of its course it receives its largest tributary, and forms in its delta one of the most extensive systems of internal navigation. The Rangoon is the only one of its 14 mouths that is always navigable, and in it the commerce of the empire is concentrated. The internal communication is extended by the junction of the two most navigable deltoid branches with the rivers Saluen and Pegu by natural canals: that joining the former is 200 miles long; the canal uniting the latter is only navigable at high water.

The Menam, one of the largest Indo-Chinese rivers, is less known than the Irrawady; it comes from the Chinese province of Yunnan, and runs through the kingdom of Siam, which it cuts into several islands by many diverging branches, and enters the Gulf of Siam by three principal arms, the most easterly of which forms the harbour of Bangkok.

The Mekon, or river of Cambodja, has the longest course of any in the peninsula; it is supposed to be the Lantsan-Kiang, which rises in the highland of K'ham, in Eastern Asia, not far from the sources of the great Chinese river, the Yang-tse-Kiang. After traversing the elevated plain of Yunnan, where it is navigable, it rushes through the mountain barriers, and is again navigable by boats on reaching a wider valley, for a distance of several hundred miles. About 360 miles from its mouth, it is hemmed in by a hilly range, and forms numerous cataracts and rapids which destroy its utility as a great artery of communication with the interior.

The ancient capital of Anam is situated on the Cambodja, about 150 miles from the sea; a little to the S. its extensive delta begins, projects far into the ocean, and is cut in all directions by arms of the river, navigable during the floods; three of its mouths are permanently so for large vessels up to the capital. The Saïing, more to the E., is much shorter than the Cambodja, though said to be 1000 miles long, but Europeans have not ascended higher than the town of Sai-Gon. Near its mouth it sends off several branches to the eastern arm of the Cambodja. All rivers of this part of Asia are subject to periodical inundations, which fertilize the plains at the expense of the mountains.

The parallelism of the mountain-chains constitutes formidable barriers between the upper basins of the Indo-Chinese rivers, and decided lines of separation between the inhabitants of the intervening valleys: but this inconvenience is in some degree compensated by the natural canals of junction and the extensive water-communication towards the mouths of these rivers.

§ 3. Four great systems of rivers take their origin on the eastern declivity of the great table-land of Central Asia, and, running from W. to E., traverse the Chinese empire:—The Hong-Kiang, rising in the province of Yunnan, empties itself into the bay of Canton. The Yang-tse-Kiang, or Son of the Ocean, descends in two main streams from the Pering Mountains, which divide China Proper from the unknown regions of Tartary, and is estimated to have a length of 3000 miles, a fifth part of which is navigable by large ships. This mighty river, next in size to the Mississippi and Amazon, is swelled by numerous affluents, chiefly from the N., but also by some on its southern shore. The former, flowing from lofty snow-clad mountains, and consequently rushing forth with great violence in the early summer, carry down vast quantities of sand and detritus, so that the main stream is either rapidly obstructed in one part of its bed or deepened in another by new and powerful currents, consequently requiring a very careful navigation. The Hoang-Ho, or Yellow River, so called from the quantity of earthy matter it carries down to the sea, is 2280 miles long. Although its source is near that of the "Son of the Ocean," the two rivers are widely separated by the mountain-chains that border the table-land: they approach each other as they proceed on their eastern course, and previous to the year 1851 were not more than 100 miles apart when they entered the Yellow Sea. In that year the river burst through its northern banks near Lan-Yang-hien in Honan, and by 1853 its lower course was wholly changed, and its waters diverted northward to a new embouchure in the Gulf of Pechili, 260 miles distant from its old mouth. No less than nine such changes are recorded by the Chinese as having taken place during the last 2500 years; the first dating about 602 B.C., and the ninth the one just described. The positions of the mouths resulting from these changes of the river-bed range over an extent of coast-line comprised within no less than five degrees of latitude. The Yang-tse-Kiang and the Yellow River, in the lower part of their course, are united by innumerable canals, forming the grandest system of irrigation and of internal navigation in existence.

Strong tides ascend these rivers to the distance of 400 miles, and for the time prevent the descent of the fresh water, which forms large interior seas, frequented by thousands of trading vessels; they irrigate the productive land of Central China, from time immemorial the most highly cultivated and the most densely peopled region of the globe.

Almost all the Chinese rivers of less note—and they are numerous—feed these giant streams, with the exception of the Ta-si or Hong-Kiang and the Pei-Ho or White River, which have their own basins. The former, rising to the E. of the town of Yunnan, flows through the plains of Canton eastward to the Gulf of Canton, into which it discharges itself, increased in its course by the Sekiang.

The White River, rising in the mountains near the Great Wall, becomes navigable a few miles E. of Pekin, unites with the Eu-ho, joins the Great Canal, and, as the tide ascends it for 80 miles, it is crowded with trading-vessels.

The Amur, the sources of which are in Mongolia and the Transbaikal country, separates in great part of its course Chinese Manchuria from the new Russian territory of Amurskaya, is 2380 miles long, including its windings, and has a basin of 582,880 square miles. Almost all its tributaries come from that part of the Baikalian group called the Yablonnoi Khrebct by the Russians, and Khing-Khan-Oola by the Chinese. It is formed by the junction of the Shilka from the N. and the Argun from the S.; and though its course is through an uninhabited country, it is celebrated as having been the birthplace and the scene of the exploits of Tshingis Khan. After passing through the lake of Dalainor, which is 210 miles in circumference, it takes the name of Argun, and forms the boundary between China and Russia for 400 miles; it is then joined by the Shilka, where it assumes the Tunguse name of the Amur or Great River: the Manchus call it the Saghalin or Black Water. It receives most of the unknown rivers which come from the mountain-slopes of the Great Gobi, takes a northern course, and falls into the Pacific opposite to the island of Saghalin, after having traversed 3° of latitude and 33° of longitude. Its mouth is frozen for seven months in the year; but in the island of Saghalin Russia possesses several fine harbours, which will enable her fleets to keep the sea throughout the year, together with extensive beds of coal capable of regularly supplying her steam navy in the North Pacific. The connection of the Baltic and the Caspian Seas is complete, and it now requires only 200 miles of additional canalization to connect the Caspian and Pacific; when that work is accomplished, the Baltic and Pacific will be united by an unbroken internal navigation of 8000 miles.

§ 4. Three great rivers, the Lena, the Yenessei, and the double system of the Irtish and Oby, not inferior in size to any of the rivers of Asia, carry off the waters of the Altaï chain, and of the mountains which bound the northern border of the great Asiatic table-land. The Lena, whose basin occupies 594,000 square miles, rises in mountains N. of the Lake of Baikal, and runs N.E. through more than half its course to Yakutsk, in Siberia, the coldest town on the face of the earth, receiving in its course the Vitim and the Olekma, its two principal affluents, the former from the Baikal Mountains, the latter from Stannovoi Khrebet, the most southerly part of the Aldan range. North of Yakutsk, about the 63rd parallel of latitude, the Lena receives the Aldan, its greatest tributary, which also comes from the Stannovoi Khrebet; it then runs to the Arctic Ocean, between banks of frozen mud, prodigious masses of which are hurled down by the summer floods, and expose to view the bones of those extinct species of elephants and rhinoceros which at some remote period had found their nourishment in these desert plains.[1] The length of the Lena, including its windings, is 2400 miles.

The Yenessei, a much larger river than the Lena, drains about 784,530 square miles, and is formed by the union of the Great and Little Kem. The former rises at the junction of the Savansk range with the Baikalian mountains to the N.W. of Lake Kassagol; the latter comes from the Egtag or Little Altaï, in quite an opposite direction, so that these two meet nearly at right angles, and take the name of Yenessei; it then crosses the Savansk range in cataracts and rapids, entering the plains of Siberia below the town of Krasnojarsk. Below this many rivers join it, chiefly the Angara from the lake Baikal; but its greatest tributaries, the Upper and Lower Tunguska, both large rivers from the Baikalian mountains, join it lower down, the first to the S., the latter to the N. of the town of Yeniseisk, whence it runs N. to the Icy Ocean, there forming a large gulf, its length, measured along its bed, being 2800 miles.

The Oby rises in the lake of Toleskoi, "the Lake of Gold," in Great Tartary; all the streams of the Lesser Altaï unite to augment its waters and its great tributary the Irtish. The rivers which descend from the northern declivity of the mountains go to the Oby, those from the western side to the Irtish. The latter springs from numerous streams on the south-western declivity of the Little Altaï, and runs westward into the Zaisan Lake, 200 miles in circumference. Issuing from thence, it takes a westerly course to the plain on the N. of Semipolatinsk, in which it is joined by the Tobol, which crosses the steppe of the Kirghiz Cossacks from the Ural Mountains, and then it unites with the Oby; the joint stream proceeds to the Arctic Ocean, into which it falls in 67° N. lat. The Oby is 2400 miles long, and the basin of these two rivers occupies a third part of the area of Siberia.

Before the Oby leaves the mountains, at a distance of 1200 miles from the Arctic Ocean, its surface has an elevation of not more than 400 feet, and the Irtish, at the same distance, is only 72 feet higher; both the currents are consequently sluggish. When the snow melts, they cover the country like seas; and as the inclination of the plains in the middle and lower parts of their course is not sufficient to carry off the water, those immense lakes and marshes are formed which characterise this portion of Siberia.

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[1] The elephant and rhinoceros of Siberia belong to extinct species whose remains are widely scattered over the whole of Europe. The Siberian individuals were covered with a thick coating of hair and fur, so different from any of their living congeners, that it suggested to Cuvier the explanation of their being able to exist in so cold a climate, where, from their extraordinary state of preservation, they must evidently have lived, their hairy coats enabling them to brave an excessive climate, whilst they found nourishment in the birch and pine forests of these high latitudes.—See Cuvier, 'Ossemens fossiles,' article "Éléphants fossiles."

The bed of the Oby is very deep; and as the water is very deep at its mouth, the largest vessels can ascend the stream as high as where the Irtish enters it. Its many affluents also might admit ships, did not the climate form an insurmountable obstacle during the greater part of the year. Indeed, all Siberian rivers are frozen annually for many months, and even the ocean along the Arctic coasts is rarely disencumbered from ice; therefore these vast rivers never can be important as navigable streams. They abound in fish and water-fowl, for which the Siberian peasant braves the extremest severity of the climate.

Local circumstances have nowhere produced a greater difference in the human race than in the basins of the great rivers N. and S. of the table-land of Eastern Asia. The Indian, favoured by the finest climate, and a soil which produces the luxuries of life, intersected with rivers navigable at all seasons, and affording easy communication with the surrounding nations, attained early a high degree of civilization, which has since been lost; while the Siberian and Samoyede, doomed to contend with the rigours of the polar blasts in order to maintain mere existence, have never risen beyond the lowest grade of humanity; but custom softens the rigour of this stern life, so that even here a share of happiness is enjoyed.

BIBLIOTHECA BODLEIANA

CHAPTER XXI.

AMERICAN AND AUSTRALIAN RIVERS.

§ 1. River-systems of North America; the Great Fish River, Coppermine, Mackenzie, and Yukon; the Saskatchewan and Red River; the Mississippi, Ohio, Missouri, and Arkansas; the Hudson, Delaware, and Susquehanna; the Oregon, Colorado, and Sacramento; the Fraser, Anderson, Thompson, and Nasse. § 2. River-systems of Central America; the Rio Montagua, Blewfields, and San Juan. § 3. River-systems of South America; Magdalena, Atrato, and Orinoco; the Amazon and its tributaries; the Rio de la Plata, Paraguay, and Colorado; the Essequibo; the Para and San Francisco, &c. § 4. Australian rivers.

§ 1. NORTH AMERICA is divided into four distinct water-systems by the Rocky Mountains, the Alleghanies, and the table-land which contains the great lakes, and separates the rivers that flow into the Arctic Ocean from those which run into the Gulf of Mexico. This table-land, which is a level, nowhere more than 1200 or 1500 feet above the surface of the sea, is the watershed of the Mississippi, the Mackenzie, the St. Lawrence, and of the rivers that flow into Hudson Bay. The St. Lawrence rises under the name of St. Louis in the Lake of the Woods to the N.W. of Lake Superior; after joining the Lakes Superior, Huron, Erie, and Ontario, it issues from the last by the name of the Iroquois, and, expanding in its north-easterly course into the Lakes of St. Francis, St. Louis, and St. Peter, it is first known as the St. Lawrence at Montreal, from whence it runs N.E., and after a course of 2000 miles it enters the Atlantic with an embouchure 120 miles wide. Its tributaries are larger than European rivers, and several of those that fall into the Ottawa are greater than the Thames. The granite capes and headlands on the gulf are of striking grandeur; the boldest and loftiest part of this granite wall is cleft by an enormous fissure, through which the Saguenay flows. The waters of this great tributary run beneath a perpendicular bank, the river being in some places a thousand feet deep.[1] The St. Lawrence has a basin of 297,600 square miles, of which 84,000 are covered with water, exclusive of the many lesser lakes with which it is in communication.

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[1] 'Quarterly Review,' Jan. 1861.

N. of the watershed there is an endless and intricate labyrinth of lakes and rivers, almost all connected with one another. But the principal streams of these Arctic lands are—the Great Fish River, now called the Back River, which flows N.E. in a continued series of dangerous and all but impassable rapids to the Arctic Ocean at Melville Strait; the Coppermine River, of much the same character, which, after traversing many lakes, enters the Icy Sea at Coronation Gulf; the Mackenzie River, a stream of greater magnitude, formed by the confluence of the Peace River and the Athabasca from the Rocky Mountains, which, after flowing N. over more than 16° of latitude, enters the Frozen Ocean, by many mouths, in the Esquimaux country beyond the Arctic Circle, in lat. 68° 50' N.; and the Colville, which enters the sea in 151° W. longitude, near Point Barrow. All these rivers are frozen more than half the year, and the Mackenzie, in consequence of its length and direction from S. to N., is subject to floods like the Siberian rivers, because its lower course remains frozen for several hundred miles long after the upper part has thawed, and the water, finding no outlet, flows over the ice and inundates the plains. The Yukon, or Kwich-pak, is a magnificent river, 2000 miles in length, draining the country to the W. of the basin of the Mackenzie. In its upper course it is called the Pelly. Near long. 147° W. it is joined by the Porcupine or Rat River on its right bank; and at this junction Fort Yukon is situated, the most distant outpost of the Hudson's Bay Company, though it is included in the territory of Alaska. In long. 158° W., the river makes a great bend southward, a course which it pursues for over 200 miles. It then turns W., and falls into Norton Sound by numerous mouths, of which the most northerly, the Aphoon, is navigable, though all are blocked up by ice till the beginning of June and freeze again in October. The Upper Yukon, which has been explored for 600 miles above the junction of the Porcupine, runs through mountain gorges; and at some distance below Fort Yukon, the heights on the banks are known as the "Ramparts," and tower grandly above the river. Many islands are formed in its course, and it is in several places obstructed by rapids, but there are none which would prevent the navigation of the river during the time it is open, by such steamers as are used on American rivers. The banks of the Yukon are in many places well wooded with pine, poplar, willow, and birch; and the river abounds in salmon.

Although the Arctic coast is so stern, a magnificent country to the S. has been for many years in possession of the British empire, which may in future be a rich and flourishing colony, but which has hitherto only supplied the London market with fur. It contains two rivers now become of great importance—the Saskatchewan and the Red River. The S. and N. branches of the former have their origin in different arms of the same huge glacier in the Rocky Mountains. The first part of the course of the southern branch is through a country that is partly arid, but the northern branch flows through prairies of great fertility. After being increased by large tributaries, the two branches unite and ultimately fall into Lake Winnipeg. The Red River rises in Ottertail Lake, in the Minnesota territory of the United States, and after cutting a winding course for 100 miles, it falls into the southern part of Lake Winnipeg. At intervals for more than 20 miles from the lake the farms, stone houses, and churches of the settlement of the Hudson's Bay Company appear on its precipitous banks, which are often covered with large timber. No part of the British territory is of greater agricultural richness, and one of the first great works of the Canadian government will be the junction of this settlement to Western Canada, as a preliminary to the inter-oceanic railway.

S. of the table-land the valley of the Mississippi extends for 1000 miles, and this greatest of North American rivers has its origin in the junction of streams from the small lakes Itaska and Ussawa, on the table-land at no greater height than 1500 feet above the sea. Before their junction these streams frequently spread out into sheets of water, and the Mississippi does the same in the upper part of its course. This river flows from N. to S. through more degrees of latitude than any other, and receives so many tributaries of the higher orders that it would be difficult even to name them. Among those that swell its volume from the Rocky Mountains, the Missouri, the Arkansas, and the Red River are the largest, each being in itself a mighty stream, receiving tributaries without number. Before their junction the Missouri is a river much superior to the Mississippi both in length and volume, and has many affluents larger than the Rhine. It rises in about 44° N. lat., and runs partly in a longitudinal valley of the Rocky Mountains, and partly at their foot, and drains the whole of the country on the right bank of the Mississippi between the 49th and 40th parallels of N. latitude. It descends in cataracts through the mountain regions, and in the plains it sometimes passes through large prairies and sometimes through dense forests, in all accomplishing 3000 miles in a very tortuous and generally south-eastern direction till it joins the Mississippi near the town of St. Louis. Lower down, the Mississippi is joined by the Arkansas, 2000 miles long, with many tributaries, and then by the Red River, the former from the Rocky Mountains; the latter, which rises in the table-land of New Mexico, is fed by rivers from the Sierra del Sacramento, and enters the main stream not far from the beginning of the delta, at the head of which the

Mississippi sends off a large branch called the Atchafalaya to the S., and then turning to the E. it discharges itself by five mouths at the extremity of a long tongue of land which stretches 50 miles into the Gulf of Mexico, having formed a delta considerably larger than that of the Nile. The shore is lined with shallow salt lagoons; the greater part of the delta is covered with water and unhealthy marshes, the abode of the crocodile, and during the floods it is a muddy sea. This river is navigable for 2240 miles. Its valley is of variable width, but at its greatest breadth, at the junction of the White River, it is 80 miles.

The tributaries from the Rocky Mountains, though much longer, run through countries of less promise than those which are traversed by the Ohio and the other rivers that flow into the Mississippi from the E., which offer advantages unrivalled even in this wonderful country, only beginning to be developed.

The Ohio is formed by the union of the rivers Alleghany and Monongahela, the latter from the Laurel ridge of the Alleghany chain in Virginia; the former has its sources near Lake Erie; and the two unite at Pittsburg, from whence the river winds for 948 miles through some of the finest states of the Union, till its junction with the Mississippi, having received many accessories, six of which are navigable streams. There are some obstacles to navigation in the Ohio, but they have been avoided by canals. Other canals join both the Mississippi and its branches with Lake Erie, so that there is an internal water-communication between the St. Lawrence and the Gulf of Mexico. The whole length of the Mississippi is 3160 miles, but, if the Missouri be considered the main stem, it is 4265, and the joint stream drains an area of about a million and a quarter of square miles. The breadth of the river nowhere corresponds with its length. At the confluence of the Missouri each river is half a mile wide, and after the junction of the Ohio it is not more. A steamer may ascend the Mississippi for 2000 miles from Balize without any perceptible difference in its breadth. The depth is 168 feet where it enters the Gulf of Mexico at New Orleans: the fall of the river at Cape Girardeau is four inches in a mile. This river is a rapid desolating torrent loaded with mud: its violent floods, from the melting of the snow in the high latitudes, sweep away whole forests, by which the navigation is rendered very dangerous at times, and the trees being matted together in masses many yards thick, are carried down by the spring floods, and deposited over the delta and Gulf of Mexico for hundreds of square miles.

North America can boast of two other great water-systems, one from the eastern declivity of the Alleghanies, which flows into the Atlantic, and another from the western side of the Rocky Mountains, which runs into the Pacific.

All the streams that flow eastward through the United States to the Atlantic are short, and of comparatively small volume, but of the highest utility, because many of them end in gulfs or estuaries, and the whole are so united by canals that there are few places which are inaccessible by water—one of the greatest advantages a country can possess. There are at least 24 great canals in the United States, the length of which is 3101 miles. This is an important addition to the already great extent of inland navigation furnished by the rivers.

Many of the streams which fall into the Atlantic rise in the western ridges of the Alleghany chain, and traverse its longitudinal valleys before leaving the mountains to cross the Atlantic slope, which terminates in a precipitous ledge for 300 miles parallel to the range. By falling over this rocky barrier in long rapids and picturesque cascades, they afford an enormous and extensive water-power; and as the rivers are navigable from the Atlantic quite across the maritime plains, these two circumstances have determined the location of most of the principal cities of the United States at the foot of this rocky ledge, which, though not more than 300 feet high, has had a greater influence on the political and commercial interests of the Union than the highest chains of mountains have had in other countries. The Hudson in the N. is navigable to Albany; the Delaware and Susquehanna, ending in bays, are important rivers; and the Potomac, which falls into Chesapeake Bay, passes by Washington, the capital of the United States, to which the largest ships can ascend.

The watershed of the Rocky Mountains lies at a greater distance from the Pacific than that of the Alleghanies from the Atlantic; consequently the rivers are longer, but they are few, and were little known till they were discovered to be so rich in gold. The Fraser, and its tributaries, the Anderson and Thompson, in British Columbia, are highly auriferous, and there is every reason to believe that the Nasse is equally so. It is more to the N., and flows between immense mountains, whose summits are covered with perpetual snow, and through a country which, like the whole of the N.W. coast of British Columbia, is one long continuous formation of slate with frequent veins of crystallized quartz, and, at intervals, indications of ancient volcanic action; the miners believe the whole district to be highly auriferous. About 110 miles from Fort Simpson the Nasse makes a rectangular turn, falling at the rate of 10 or 12 feet in a mile: the water rushes furiously, forming below the angle a whirlpool 300 feet in circumference, upon the outer edge of which the waters boil up from beneath as from a caldron, raising the level of the current several feet, and then bursting with a fury that carries everything before it; and about three miles lower down the river forms a regular cascade, and falls into the Pacific in 54° 40′ N.

Only patches of land are fit for cultivation, but 80 miles from the mouth of the river the Indians plant great crops of potatoes, so that a mining establishment might be supplied with food.

The peculiar nature of that part of the watershed of the Rocky Mountains that belongs to British Columbia was first brought into notice by Mr. John Ball. "Except in the Carpathian chain, we have nowhere in the Old World anything exactly like it. The rivers seem to pass across the axis of greatest elevation. The two main branches of the Saskatchewan River pass to the westward of the highest mountains in the chain, Mount Murchison and Mount Hooker; and on the western side of the chain we have this extraordinary fact—two rivers flowing parallel to each other, a few miles apart, for a long distance, the Columbia and the Kutanie, one running to the N.W. and the other to the S.E. It is one of the most singular facts in physical geography." The largest of the rivers W. of the Rocky Mountains are the Oregon or Columbia, and the Rio Colorado. The former has its sources not far from those of the Missouri and of the Rio del Norte; and after an exceedingly tortuous course, in which it receives many tributaries, it falls into the Pacific at Astoria. The Colorado comes from the Sierra Verde, and falls into the Gulf of California. It is formed by the junction of the Green and Grand Rivers, and receives numerous tributaries, of which the San Juan, the Colorado Chiquito, and the Gila are the chief. The basin of the Colorado has an area of 200,000 square miles, and is bounded on the E. by the Sierra Madre of New Mexico, and on the N.W. by the Wahsatch Mountains. It is of a triangular shape, and consists of successive table-lands of from 4000 to 7000 or even 8000 feet in elevation, having abrupt edges and barren surfaces. Through these table-lands the Colorado and its tributaries have worn deep and remarkable gorges, called cañons, the largest of which is the great cañon of the Colorado, which has a length of 300 miles. The sides of this gorge rise from 1000 feet to nearly a mile in perpendicular height. The parts of the table-land which are traversed by these cañons are barren, as all the water flows away in the deep valleys, and tributary streams come to the chief river through tributary cañons.[1]

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[1] The word cañon is used to express the clefts through which many of the rivers of the west of America flow for long distances. Sometimes the term is applied to a mountain-gorge, as the cañon of the Fraser in British Columbia, and sometimes to such a gorge as that describe l as occurring in the course of the Colorado. In every case, cañons are the result of the eroding action of the river, and no rocks, however hard, are found capable of resisting it.

The Wahsatch Mountains, which have a breadth of 60 miles, separate the Colorado basin from what is called the Great Basin, which lies W. and N.W. of the range, and has an area of 280,000 square miles. This is watered by numerous small streams which flow into salt lakes. The Humboldt is one of the largest of the rivers found in the Great Basin; and the Great Salt Lake, near which is the Mormon settlement, is one of the chief lakes. The Sacramento with its tributaries, a Californian stream, lies W. of the Sierra Nevada, and flows through an extensive and rich auriferous country in its course to the Bay of San Francisco on the Pacific.

On the table-land of Mexico there is a basin of continental streams, which, rising from springs on the eastern side of the Sierra Madre, and fed by the periodical rains, flow northward, and terminate in lakes, which part with their superfluous water by evaporation. Of these the Rio Grande, which, after a course of 300 miles, falls into the Parras, is the greatest.

The largest river in the isthmus of Mexico is the Rio Tololatlan, or Rio Grande di Santiago, which rises on the table-land of Toluca, forms numerous cascades, and falls into the Pacific after a course of 400 miles. The river of Goatzacoalcos, which traverses the isthmus nearly from sea to sea, emptying itself into the Gulf of Mexico, has by some been considered as the best point for a sea-canal between the two oceans.

§ 2. There are many streams in Central America, and above ten rivers that are navigable for some miles; six of these fall into the Gulf of Mexico and Caribbean Sea, and four into the Pacific. Of these are the Rio Montagua, which, rising in the mountains near Guatemala, flows into the Gulf of Honduras, and the Blewfields River, the greater part of whose course is in the Mosquito territory.

In the southern part of the State of Guatemala is situated the river of San Juan, which drains the lakes of Nicaragua and Leon, and by which it is supposed a water-communication could be easily effected between the Atlantic and the Pacific.

§ 3. The Andes, the extensive watershed of South America, are so close to the sea, that there are no rivers of considerable size which empty themselves into the Pacific; even some of the streams that rise in the western cordilleras find their way to the eastern plains.

The Magdalena, at the northern end of the Andes, though a secondary river in America, is 620 miles long. It rises in the central chain, at the divergence of the cordilleras of Suma Paz and Quindiu, and enters the Caribbean Sea by various channels: it is navigable as far as Honda. The Cauca, its only feeder on the W., comes from Popayan, and is nearly as large as its primary, to which it runs parallel the greater part of its course. Many streams join the Magdalena on the right, as the stream which waters the elevated plain of Bogota, and forms the cataract of Tequendama, one of the most beautiful and wildest scenes in the Andes. The latter river rushes through a chasm 30 feet wide, which appears to have been formed by an earthquake, and at a double bound descends 530 feet into a dark gloomy pool, illuminated only at noon by a few feeble rays. A dense cloud of vapour rising from it is visible at the distance of 15 miles. At the top the vegetation is that of a temperate climate, while palms grow at the bottom.

The river Atrato, parallel to the Cauca and Magdalena, but less considerable, empties itself into the Gulf of Darien. The rivers of Patia, of San Suan, of Las Esmeraldas, and of Guayaquil, all rise on the western declivity of the Andes to flow into the Pacific. With these exceptions all the water from the inexhaustible sources of the Andes N. of Chile is poured into the Orinoco, the river Amazon, and the Rio de la Plata, which convey it across the continent to the Atlantic. In the far south, indeed, there are the Colorado and Rio Negro, but they are insignificant when compared with the three giant floods above named.

The basins of these three rivers are separated in their lower parts by the mountains and highlands of Guiana and Brazil; but the upper parts of the basins of all three form an extensive level, and are only divided from one another by imperceptible elevations in the plains, barely sufficient to form the watersheds between the tributaries of these majestic rivers. This peculiar structure is the cause of the natural canal of the Cassiquiare, which joins the Upper Orinoco with the Rio Negro, a principal affluent of the Amazon. Ages hence, when the wilds are inhabited by civilized man, the tributaries of these three great rivers, many of which are navigable to the foot of the Andes, will, by means of canals, form a water-system infinitely superior to any that now exists.

The Orinoco rises in the Sierra del Parima, 200 miles E. of the elevated Peak of Duida, and maintains a westerly course to San Fernando de Atabapo, where it receives the Atabapo, and Guaviare, which is larger than the Danube; here ends the Upper Orinoco. The river then forces a passage through the Sierra del Parima, and runs due N. for three degrees of latitude, between banks almost inaccessible; its bed is traversed by dykes, and filled with boulders of granite and islands clothed with a great variety of magnificent palm-trees. Large portions of the river are here engulfed in crevices, forming subterranean cascades; in this portion are the celebrated falls of the Atures and Apures, 36 miles apart, which are heard at the distance of many miles. At the end of this tumultuous part of its course it is joined by the Meta, and farther N. by the Apure, two very large rivers, which drain the whole eastern side of the

Andes in an extent of 10 degrees of latitude; it then runs eastward to its mouth, where it forms an extensive delta, and enters the Atlantic by many channels. As the Upper Orinoco runs W., and the Lower Orinoco E., it makes a complete circuit round the Parima mountain system, so that its mouth is only two degrees distant from the meridian of its sources.

The Cassiquiare leaves the Orinoco near the S. base of the Peak of Duida, and joins the Rio Negro, a chief tributary of the Amazon, at the distance of 180 miles.

The Orinoco is navigable for 1000 miles at all times of the year; a fleet might ascend it from the Dragon's Mouth to within 45 miles of Santa Fé de Bogota. It receives many navigable rivers, of which the Guaviare, the Atures, and the Meta are each larger than the Danube. The Meta may be ascended to the foot of the Andes; its mean depth is 36 feet, and in many places 80 or 90. It rises at so great an elevation in the Andes that Humboldt says the vegetable productions at its source differ as much from those at its confluence with the Orinoco, though in the same latitude, as the vegetation of France does from that of Senegal. The larger feeders of the Orinoco come from the Andes, though many descend to it from both sides of the Parima, in consequence of its long circuit among these low mountains.

The basin of the Orinoco has an area of 300,000 square miles, of which the upper part is one impenetrable forest; the lower consists of those extensive plains called Llanos.

The floods of the Orinoco, like those of all rivers entirely within the torrid zone, are very regular, and attain their height nearly at the same time with those of the Ganges, the Niger, and the Gambia. They commence rising about the 25th of March, arrive at their greatest height, and begin to decrease, about the 25th of August. The inundations are very great, owing to the quantity of rain that falls in the regions close to the Andes, which is said to exceed 1000 inches in a year.

Below the confluence of the Apure the river is three miles and a quarter broad, but during the floods it is three times as much. By the confluence of four of its greatest tributaries at the point at which it bends to the E., a low inland delta is formed, in consequence of which 3600 square miles of the plain are under water during the inundations.

Upper Peru is the cradle of the Amazon, the greatest of rivers, which drains the chain of the Andes from the equator to the 20th parallel of southern latitude. Its highest branch, which bears the name of Marañon, issues in two streams from the lake of Lauricocha in the plain of Bombon, at a great elevation in the Andes 32 leagues N.W. from the city of Lima: it runs in a deep longitudinal valley from S. to N., till it bursts through the eastern ridge at the Pongo de Manseriche, near the town of San Borja, from whence it follows an uniform eastern course of more than 3000 miles, including its windings, till it reaches the Atlantic. W. of San Borja, and on its southern bank, it receives the Huallaga and Yucayali, the latter a river of great size, which rises in the Andes of Vilcañota, S. of Cuzco, where its source was visited and its position determined by Mr. Pentland in 1838. The river Amazon is supposed to drain an area of two millions and a half of square miles, which is ten times the area of France. In some places it has a great depth; it is navigable by its tributary the Yucayali as far as 3600 miles from its mouth, where it is 96 miles wide.

The name of the river is three times changed in its course: it is known as the Marañon from its source to the Brazilian frontier; from that point to its junction with the Rio Negro it is called the Solimoës; and from the Rio Negro till it enters the ocean it is the river Amazon.

The number, length, and volume of its tributaries are in proportion to its magnitude; even the affluents of its affluents are noble streams. More than 20 superb rivers, 1000 miles and upwards in length, pour their waters into it, and streams of less importance are numberless. Two of the largest are the Huallaga and the Yucayali: the former has its origin near the mining district of Pasco, and after a long northern course between the cordilleras it breaks through a gorge similar to that of Manseriche and joins the Marañon in the plains; it is almost a mile broad above its junction. The Spanish governor of Peru sent Pedro de Orsua down this river in the year 1560 to search for the lake of Parima and the city of El Dorado. The Yucayali, not inferior to the Marañon itself, is considered by some eminent geographers to be the trunk-stream of this colossal river-system. In a course of 1200 miles it is fed by tributaries from a wide extent of country, and at its junction with the main stream, near the mission of San Joaquim de Omaguas, a line of 50 fathoms does not reach the bottom, and in breadth it is more like a sea than a river. By this stream and its western tributary, the Pachitea, there is access to Southern Peru within 200 miles of Lima, and there is communication between the Amazon and the most distant regions around by other navigable feeders. It is only recently, through the enterprise of a private English gentleman, Mr. W. Chandless, that anything has been made known of the rivers that empty themselves into the Amazon on its southern bank, between the Yucayali and the Madeira; one of the principal is the Purus, a noble river, 1880 miles in length; it rises in the forest-plains E. of the Yucuyali, and not in the Andes, at an elevation of about 1100 feet only. It flows, throughout the whole of its long winding course, through a plain of extreme fertility covered with an uninterrupted forest, and is navigable by steamers for about 1000 miles. The Madeira, which is the greatest affluent of the Amazon, and nearly 2000 miles in length, rises near the sources of the Paraguay, the principal tributary of the Rio de la Plata. The Amazon is not less extensively connected on the N. The high lands of Colombia are accessible by the Putumayo, the Japurá, and other great navigable rivers; the Rio Negro, several miles broad a little way above its junction with the Amazon, connects it with the Orinoco by the Cassiquiare; and lastly, the sources of the Rio Branco approach very near to those of the Essequibo, an independent river of Demerara.

The main stream, from its mouth nearly throughout its length, is full of islands, and most of its tributaries have deltas at their junction with it. The annual floods of the Amazon are less regular than those of the Orinoco, and, as the two rivers are on opposite sides of the equator, they occur at different seasons. The Amazon begins to rise in November, is at its greatest height in the beginning of June, and its least in September and October. The Amazon separates into two branches at its mouth, of which one joins, by several long and very narrow channels, the Parà S. of the island of Marajo; the other enters the ocean to the N. of it.

The water of some of the rivers in equatorial America is whitish; in others it is of a deep coffee-colour, or dark green when seen in the shade, but perfectly transparent, and, when ruffled by a breeze, of a vivid green, like some of the Swiss lakes. In Scotland the brown waters derive their colour from peat-mosses; but it is not so in America, since they occur as often in forests as in savannahs. Sir Robert Schomburgk thinks they are coloured by ores of iron imbedded in the granite over which they flow; however, the colouring matter has not been chemically ascertained. The Orinoco and the Cassiquiare are milky; the Rio Negro, as its name implies, is black, yet the water does not stain the rocks, which in some places are of a dazzling white.

The Rio de la Plata forms the third great river-system of South America. The Rio Grande, its principal stream, rises in the mountains of Minas Geraes, in Brazil, and runs 500 miles on the table-land from N. to S. before it takes the name of Paranà. For more than 100 miles it is a continued series of cataracts and rapids, the greatest of which, the Salto Grande, is in about lat. 24° 5′. Above the fall the river is three miles broad, when all at once it is contracted in a rocky pass only 60 yards wide, through which it rushes over a ledge with thundering noise, heard at the distance of many miles. The Paranà receives three large rivers on the right—the Paraguay, the Pilcomayo, and the Vermejo; all trend to the S.E., and unite at different distances before entering their primary at Corrientes. The Paraguay, 1200 miles long, is the largest of the three: in its upper part it is singularly picturesque, adorned with palms and other tropical vegetation; its islands are covered with orange-groves. It springs from a chain of seven lakes, on the southern slopes of the Campos Parecis, in Brazil, and may be ascended by vessels of considerable burthen through 19° of latitude. The Pilcomayo and Vermejo both come from Bolivia, and both traverse the Gran Chaco, inhabited by savage tribes; the former joining the Paraguay opposite Asuncion, and the latter near Pillar. The Salado, which runs into the Paranà, might be rendered navigable as far as the province of Salta; it would open an extensive country to commerce. At Rosario the Paranà turns eastward to form the Plata proper, and before entering the Atlantic is augmented by the Uruguay from the N.

The Rio de la Plata is 2700 miles long, and for 200 miles from its mouth, up to Buenos Ayres, it is more like a great sea estuary than a river, being never less than 170 miles broad. Were it not for the freshness of its water, it might be mistaken for the ocean: it is, however, shallow and loaded with mud, which discolours the Atlantic for 200 miles from its mouth.

The Paraguay is subject to great floods, which carry destruction and desolation with them. The atmosphere at times is poisoned by the putrid carcases of drowned animals brought down by it. The ordinary annual inundations of the Paranà, the principal or upper branch of the Plata, cover 36,000 square miles.

The Colorado, which runs in a long shallow stream through the Pampas of Buenos Ayres, is formed of two principal branches, one from the W. and the other from the N., which unite at a great distance from the Atlantic, into which the river flows.

The Rio Negro rises at a great elevation on the western declivity of the Andes, and separates the Pampas from Patagonia. In its long course through arid deserts to the Atlantic it does not receive a single tributary, but it forms a communication between that ocean and Chile, as it reaches a pass in the Andes that is free from snow. There is some vegetation in its immediate neighbourhood; it has a bar at its mouth, and is navigable only for four miles above Carmen; it has periodical floods twice in the year, one produced by the rains, the other by the melting of the snow in the Andes.

There are various rivers in South America, unconnected with those described, which in any other country would be esteemed of a high order. Of many which descend from the high country of Guiana, the Essequibo is the largest; its general width is a mile and a quarter; its water, though black, is clear; and on its banks, and those of all its tributaries, the forest reigns in impenetrable thickness. It rises in the Sierra Acaray, which separates its basin from that of the Amazon, and, after a northerly course, falls into the Atlantic near 7° N. lat. by an outlet 14 miles broad, separated by three low islands into four branches. Sir Robert Schomburgk, whose journeys have made us acquainted with a country of which so little was known, has shown that, by cutting a canal three miles long between the Madeira and the Guapore, an affluent of the Mamore, an inland navigation might be opened from Demerara to Buenos Ayres, over an extent of 42° of latitude, with the exception of a portage of only 800 yards in the rainy season between Lake Amucu and the Quatata, a branch of the Rupununi, which flows into the Essequibo. "If," says the distinguished traveller already mentioned, "British Guiana did not possess the fertility which is such a distinguishing feature, this water-communication alone would render it of vast importance; but, blessed as it is with abundant fruitfulness, this extensive inland navigation heightens its value as a British colony; and, if emigration sufficient to make its resources available were properly directed thither, the port of Demerara would rival any in the vast continent of South America." It is certainly remarkable that the tide of emigration has never set towards a country of such promise, abounding in valuable natural productions, and so much nearer to Great Britain than her colonies in the Pacific.

The Parà and São Francisco are the chief rivers of Brazil: both rise on the table-land; the Parà is formed by the Tocantins and numerous other rivers flowing from the S. The Tocantins, descending from the highlands in rapids in its northerly course, after running 1500 miles, is joined by the southern branch of the Amazon before entering the Atlantic as the Parà, S. of the island of Marajo. The São Francisco is 1814 miles long; it rises in the Serra da Canastra, the central platform of the province of Minas Geraes, and, after running northward between mountain ranges parallel to the coast, it breaks through them, and reaches the ocean about 10° 50′ S. lat. The principal stream bursts from the gap of a perpendicular rock, more than 1000 feet high. Its early course, when it is little more than a mountain-torrent, is eastward. It then flows N., with the Serra Grande or Espinhaço on the E., and the Mata da Corda as the western wall of its valley; at the end of its course its direction is south-easterly. It receives several tributaries, the chief of which is the Rio das Velhas, in whose valley are the principal gold mines of Minas Geraes. Its course is in several places obstructed by rapids, and about 180 miles above its mouth occur the Great Rapids and Waterfall of Paulo Affonso, recently visited and described by Captain Burton. Above and below the fall about 75 miles are unnavigable. Above the fall occur the rapids of the Itaparíca, where the waters, "spuming and whirling from the prison walls of iron, rush roaring into one another's arms; all is dark and lurid as a river of the 'Inferno.'" The Paulo Affonso is very grand. At the principal cataract, the gorge is 260 feet deep, and in the narrowest part choked to a minimum breadth of 51 feet. The height of the Great Cataract is 192 feet; but the Paulo Affonso is really a succession of rapids and caldrons, ending in a mighty fall, whose "thunder" is heard at some miles distant. The fall plunges into a ravine whose black sides, from 570 to 250 feet high, wall in the stream for 42 geographical miles below the cataract The river is not continuously navigable, though steamers ply on the lower Rio de São Francisco, and many portions of the upper part might be rendered navigable without much difficulty. The river valley is very fertile; "here the sugar-cane and the pine-apple may be seen by a spectator, standing in the barley-field and the potato-patch." Cattle, sheep, and goats are easily reared in the uplands. Silk and cotton are produced. Of minerals are found diamonds, agates, gold, iron, platina, lead, mercury, copper, antimony, &c., and many building stones. Salt, saltpetre, sulphur, and alum are found in large deposits. All the vegetables of temperate and sub-tropical regions will grow in the valley; and timber and dye-woods are abundant. The country is very fit to receive emigrants. As in the Appalachian chain, so here, many rivers cross the edge of the table-land to the level maritime plains of the Atlantic.

The historical renown and the high civilization of Asia and Europe, their great wealth and population, may be attributed in a very great degree to the facility of transport afforded by their admirable river-systems, and still more to the genius of the people who knew how to avail themselves of them; the same may be said of the inhabitants of the United States of America—while the Indians of both the American continents, who have possessed these countries for ages, never took advantage of the noble streams with which Providence had enriched and embellished their country, it being left to the Anglo-Saxon race to make them one of the great sources of unparalleled prosperity.

RIVERS OF AUSTRALIA.

§ 4. After America, the land of the river and the flood, Australia appears in more than its usual aridity. The absence of large perennial rivers is one of the greatest impediments to the improvement of this continent.

The streams from the mountains on the eastern side of the continent are mere torrents, and would have short courses did they not run in longitudinal valleys; the Hawkesbury, Clarence, Brisbane, Fitzroy, and Burdekin are the largest of the rivers which empty themselves on the E. coast.

The most important river of the continent flows to the southern coast. It is formed, in the first place, of the Murrumbigee, which rises in the coast range W. of St. George Lake, and, running S.W., meets the Lachlan, flowing from the E. After their junction they run into the Murray, a much larger stream, though only 350 feet broad, and not more than 20 feet deep. Lower down the Darling enters the Murray, and is the largest of its affluents, draining the W. declivity of the mountains of South Wales, between 26° and 31° S. lat.; as the Lachlan, the Murrumbigee, and the Murray do the S. portion of the same high lands, and the northern declivity of the auriferous region of the colony of Victoria. The breakers at the mouth of the Murray are dangerous, but may be passed in fine weather in a good steamer.

The Murray has been navigated for 2650 miles, a considerable distance farther will probably be reached through some of its tributaries, and several of the rivers may be ascended to a greater distance than was supposed to be possible.

The Macquarrie is one of the principal tributaries of the Darling; after running 300 miles N.W. it passes through marshes, and afterwards enters that river. In its upper course the Darling is called the Barwan. In addition to the Castlereagh, the Macquarrie, and the Bogan, which are its chief tributaries from the S., it receives from the N. the Ballone and the Warrego.

The western slope of the coast range N. of lat. 25° S. is drained by the Thomson with its tributary, the Barcoo. This river has a course of about 600 miles in length, and finds its way to Cooper's Creek, towards which certain other streams or creeks also flow, thus forming an internal continental basin. The Parroo River, between the Warrego and the Thomson, loses itself in the sand. None of the rivers which drain the northern part of the western slope of the eastern range, nor the southern slope of the heights which encircle the Gulf of Carpentaria, ever reach the sea.

The Blackwood, the Swan, the Murchison and the Gascoyne, the Fortescue and the De Grey, drain the western side of the continent, and along the banks of some of these are fertile grassy plains. The Victoria, opening into Queen's Channel, in N.W. Australia, was explored by Mr. A. C. Gregory, in 1856.

The streams opening into the Gulf of Carpentaria are inconsiderable in length, as they descend only from the semicircular range of hills that enclose this extensive tropical sea; the Roper, the Albert, the Flinders, and the Mitchell are the largest of these rivers. The want of water makes it difficult to explore the interior of this continent. It appears that in certain groups of years there are great falls of rain over large portions of the plains, which become saturated with water; lakes are formed, and temporary streams; what is not evaporated sinks into the earth, and may supply artesian wells; Stuart found, in his journeys N. from Adelaide, that he could frequently obtain water by digging. Then years succeed in which no rain falls. Wherever there is moisture there is fertility, so in the central arid part of the interior there are productive oases alternating with unproductive tracts, and the most recent explorations have shown that the interior of Australia possesses much more water than the early travellers reported.

CHAPTER XXII.

LAKES.

§ 1. General description of lakes. § 2. European lakes; Northern Europe; Pyrenees, Alps, and Italian peninsula. § 3. Asiatic lakes; lake of Tiberias and Dead Sea; the Caspian; lakes of Aral, Baikal, and of the Himalaya; sacred lakes of Manasarowar. § 4. African lakes; Ngami; Chad, Nyassa, and the Equatorial Lakes. § 5. American lakes; Superior, Huron, Michigan, Erie, and Ontario; Nicaragua and Leon; Lake Xarayos; Lake Titicaca.

§ 1. THE hollows formed on the surface of the earth by the ground sinking or rising, by earthquakes, craters of extinct volcanoes, the intersection of strata, and by ancient glaciers, are generally filled with water, and constitute systems of lakes, some salt and some fresh. Many of the former may be remnants of an ancient ocean, left in the depressions of its bed as the waters retired when the continents were raised above its surface.

Many lakes are fed by springs rising at the bottom, and they are occasionally the sources of the largest rivers. Some have neither tributaries nor outlets; the greater number have both. The quantity of water in lakes varies with the seasons everywhere, especially from the melting snow on mountain-chains and in high latitudes, and from periodical rains between the tropics. Small lakes occur in mountain-passes, formed by water which runs into them from the surrounding peaks; they are frequently, as in the Alps, very transparent, of a bright green or azure hue. Large lakes are common on table-lands, and in the valleys of mountainous countries, but the largest are on extensive plains. The basin of a lake comprehends all the land drained by it; consequently it is bounded by an imaginary line passing through the sources of all the waters that fall into it.

§ 2. There are more lakes in high than low latitudes, because evaporation is much greater in low latitudes than in high, and in this respect there is a great analogy between the northern plains of the two principal continents. Sheets of water of great beauty occur in the mountain valleys of the British Islands, of Norway, and Sweden, countries similar in geological structure; and besides these there are two regions in the Old World in which lakes particularly abound. One begins on the low coast of Holland, encircles the southern and eastern sides of the Baltic, often passing close to its shores, along the Gulf of Bothnia, and from thence through the Siberian plains to Behring Strait. The lakes which cover so much of Finland and the great lakes of Ladoga and Onega lie in a parallel direction; they occupy transverse rents which had taken place across the palæozoic strata, while rising in a direction from S.W. to N.E., between the Gulf of Finland and the White Sea; that elevation was, perhaps, the cause of the cavities now occupied by these two seas. Ladoga is the largest lake in this zone, having a surface of 6633 square miles, according to the recent survey of M. Andreyeff. It receives tributary streams, and sends off its superfluous water by rivers, and Onega does the same; but the multitude of small steppe lakes among the Ural Mountains and in the basin of the river Oby neither receive nor emit rivers, being for the most part mere ponds, though of great size, some of fresh and some of salt water, lying close together—a circumstance which has not been accounted for: those on the low Siberian plains have the same character.

In the Pyrenees lakes are most frequent on the French side; many are at such altitudes as to be perpetually frozen; one on Mont Perdu, 8393 feet above the sea, has the appearance of an ancient volcanic crater. There is scarcely a valley in the Alpine range and its offsets that has not a sheet of water, filling cavities formed during the elevation of the ridges, by subsidence of the soil and afterwards scooped out by glaciers: Lake Trub, 7200 feet above the level of the sea, is the most elevated. Lakes are more numerous on the N. than on the S. of the Alps—the German valleys are full of them. In Bohemia, Gallicia, and Moravia there are no less than 30,000 sheets of water, besides numerous others in Austria proper.

Of the principal lakes on the northern side of the Alps, the Lake of Geneva, or Lake Leman, is the largest and most beautiful, from its situation, the pure azure of the waters, and the sublime mountain scenery that surrounds it. Its surface, of about 240 square miles, is 1230 feet above the sea, and near Meillerie it is 1012 deep. The Lake of Lucerne is 1407 feet above the sea, and the lakes of Brienz 1900 feet. The Italian lakes are at a lower level; the Lago Maggiore has only 678 feet of absolute altitude; the Lake of Como, 702; and the Lake of Garda, 320; they are larger than most of those on the N. of the Alps, and, with the advantage of an Italian climate, sky, and vegetation, they surpass the others in beauty, though the mountains that surround them are less lofty.[1]

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[1] It appears that most of the Swiss lakes, and some of the Italian, had

These great lakes are fed by rivers rising in the glaciers of the higher Alps, and many large rivers issue from them. In this respect they differ from most of the lakes in Central and Southern Italy, some of which are craters of ancient volcanoes, or perhaps ancient craters of elevation, where the earth had been swelled up by subterranean vapour without bursting, and had sunk down again into a hollow when the internal pressure was removed.[1]

§ 3. In Syria, the Lake of Tiberias and the Dead Sea, memorials sacred to the Christian world, are situate in the deepest depression on the earth's surface, the bottom of the latter being upwards of 2600 feet below the level of the ocean. The surface of Lake Tiberias is 652 feet below that of the Mediterranean, surrounded by verdant plains; while the dense bitter waters of the Dead Sea, forming an expanse 42 miles long and from 12 to 16 wide, 1292 feet below the Mediterranean, lie in a scene of great desolation and solitude, encompassed by desert sands, and bleak, stony salt-hills. Thus there is a difference of level of 640 feet in little more than 60 miles, which renders the current of the Jordan very rapid. The water of the Dead Sea is so acrid from the large proportion of saline matter it contains that it irritates the skin; it is more buoyant, and has a greater proportion of salt, than any that is known except the small lake of Eltonsk, E. of the Volga. "The salt-mountain of Jebel Usdum is the most interesting phenomenon about the lake—a long mass of rock salt, about seven miles long, and from one and a half to three miles wide, several hundred feet high, capped along its jagged top by a mass of gypsum and marl, extending S. from the south-western corner of the lake. Through this salt-mountain several streams percolate, continually bearing additional solutions of salt into the bitter and almost saturated waters. The water of the lake, where saltest, contains 28 parts of solid salt to 72 of water, but it varies much in different parts, owing to the inflow of fresh

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been inhabited by a primitive race of mankind of which no record remains, who built their huts upon stakes driven into the bottom of the lake, and thus lived on the surface of the water, probably as a refuge from enemies on land. Those stakes that are below the surface of the water were long known to the fishermen, who avoided them as destructive to their nets, but of late they have excited much interest on account of the numerous implements that have been found by excavating between the stakes. The custom is now followed by some tribes in the Pacific islands, and on many parts of the river Zambesi the Africans build their huts on stakes 20 feet above the ground, that in the rainy season they may not be endangered by the floods, which are constant and sudden. During this time it is not unusual for a native to indulge in the luxury of fishing out of his bed. In 1855 thousands of the natives were drowned by the river rising higher than usual.

[1] The Lakes of Perugia or Thrasymene and Fucino are exceptions.

water."[1] The Lake of Assal, in the Somali country, nearly opposite to Aden, resembles the Syrian lakes in many respects: its surface is 570 feet below the sea-level, and its circumference 16 miles. Separated from the ocean by a barrier of lava, it probably owes its formation, like the Dead Sea, to a barrier raised by volcanic agency between it and the Red Sea at a comparatively recent period.

Though extensive sheets of water exist in many parts of Asia Minor, especially in Bithynia, yet the characteristic feature of the country, and of all the table-land of Western Asia and the adjacent steppes, is the number and magnitude of the saline lakes. A region of salt-lakes and marshes extends at least 200 miles along the northern foot of the Taurus range, on a very elevated part of the table-land of Anatolia. There are also many detached lakes, some exceedingly saline. Fish cannot live in the Lake of Toozla; it is shallow, and subject to excessive evaporation. Neither can any animal exist in the Lake of Shahee or Urumiah, on the confines of Persia and Armenia, 300 miles in circumference; its water is perfectly clear, and contains a fourth part of its weight of saline matter. These lakes are fed by springs, rain, and melted snow, and, having no outlets, the surplus water is carried off by evaporation.

It is possible that the volcanic soil of the table-land may be the cause of this exuberance of salt water. Lake Van, a sheet of salt water, 240 miles in circumference, is separated from the equally salt lake Urumiah only by a low range of hills; there are many pieces of fresh water in that neighbourhood, possibly in similar hollows.

Persia is singularly destitute of water; the Lake Zeistan or Hamoon, on the frontiers of Afghanistan, having an area of 18 square miles, is the only piece of water on the western part of the table-land of Iran. S. of it is the great Zurrah marsh.

It is evident from the saline nature of the soil, and the shells it contains, that the plains round the Caspian, Lake Aral, and the steppes, even to the Ural Mountains, had once formed part of the Black Sea; 57,000 square miles of that country are depressed below the level of the ocean—a depression which extends northwards beyond the town of Saratov, 300 miles distant from the Caspian. Sir Roderick I. Murchison is of opinion that the great areas of land which surround the present Caspian, and which now separate it from Lake Aral, have been elevated into their present positions from a former great interior depression on the earth's surface. The surface of the Caspian itself, which is 83 feet below the level of the ocean, is its lowest part, and has an area of 140,000 square miles, nearly equal to that of Great Britain and Ireland. In Europe alone it drains an extent of 850,000 square miles, receiving the Volga, the Ural, and other great rivers on the N. It has no tide, and its navigation is dangerous from heavy gales, especially from the S.E., which drive the water miles over the land: a vessel was stranded 46 miles inland from the shore. It is 300 feet deep in the centre, but is shallower to the E., where it contains several islands, and where it is bounded by impassable swamps many miles broad. It is less salt than the ocean. The Lake of Eltonsk, on the steppe E. of the Volga, has an area of 130 square miles, and furnishes two-thirds of the salt consumed in Russia. Its water yields 29·13 per cent. of saline matter, and from this circumstance is more buoyant than any other known.[1]

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[1] Tristram's Natural History of the Bible.

The Lake of Aral, which is shallow, is 117 feet higher than the Caspian, and has an area of 23,300 square miles: it has its name from the number of small islands at its southern end, Aral signifying "island" in the Tartar language. Neither the Caspian nor the Lake of Aral has any outlets, though they receive large rivers; they are salt, and, in common with all the lakes in Persia, they are decreasing in extent, and becoming salter, the quantity of water supplied by tributaries being less than that lost by evaporation. Most of the rivers that run into the Lake of Aral are diminished by canals, that carry off water for irrigation; for that reason a very small portion of the waters of the Oxus reaches the lake. Besides, the Russian rivers yield less water than formerly from the progress of cultivation. The small mountain-lake Sir-i-Kol, in the high table-land of Pamir, from whence the Oxus flows, is 15,630 feet above the sea; consequently there is a difference of level between it and the Dead Sea of nearly 17,000 feet.

The small number of lakes in the Himalaya is one of the peculiarities of these mountains. The Lake of Wuler, in the valley of Cashmere, is the only one of any magnitude; it is but 10 miles in length and 4½ in breadth, but seems to be the residue of one that had filled the whole valley at a very remote period. There are many great lakes, both fresh and salt, on the table-land; the annular form of Lake Yamdokcho, north of the Himalaya, as represented on maps, is unexampled; the sacred lakes of Manasarowar and of R'akas Tal, in Great Tibet, occupy a space of about 400 square miles, between the gigantic peaks of Gurla on the S. and of Kailas on the N.; it is from the most westerly of these lakes (which are said to communicate with each other) that the Sutlej rises, at an elevation of 15,250 feet above the level of the sea. Tibet abounds in small lakes, some of which contain borax in solution. As most of the great lakes on the table-land are in the Chinese territories, strangers have not had access to them; the Koko-nor and Lake Lop seem to be very large; the latter is said to have a surface of 2187 square miles, and there are others not inferior to it in the N. The lakes in the Altaï Mountains are beautiful, larger and more numerous than in any other mountain-chain. They are at different elevations on the terraces by which the table-land descends to the plains of Siberia, and are, owing to geological phenomena, essentially different from those which have produced the Caspian and other steppe lakes. They seem to have been hollows formed where the axes of the different branches of the chain cross, and are most numerous and deepest in the eastern Altaï. Baikal, the largest mountain lake, supposed to owe its origin to the sinking of the ground during an earthquake, has an area of 14,800 square miles, nearly equal to the half of Scotland. It lies buried in the form of a crescent, amid lofty granite mountains, which constitute the edge of the table-land to the S., ending in the desert of the Great Gobi; in the N.W. the hills gird the shore so closely that they dip into the water in many places; 160 rivers and streams fall into this lake, which drains a country probably twice the area of Britain. The river Angara, which runs deep and strong through a crevice at its eastern end, is its principal outlet, and is supposed to carry off but a small proportion of its water. Its surface is 1703 feet above the sea-level, and the climate is as severe as it is in Europe 10° farther N.; yet the lake does not freeze till the middle of December, possibly from its depth, being unfathomable in some places with a line of 600 feet.

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[1] The water of the Dead Sea contains 26·24 per cent. of saline ingredients, one of which is sulphate of magnesia.

Lake Nor-Zaisan, situated between 47° 40′ and 48° 20′ N. lat., and between 83° 10′ and 84° 50′ E. long., spreads itself out in a broad and elevated valley, surrounded by mountain-ranges on three of its sides: the Altaï on the N.E., the Kolbinsk on the N.W., and the Tarbogatai range on the southern side. The waters of the lake are transparent, soft, and good for cooking purposes. It abounds in fish. It is frozen over from November to May, and its level rises during June and July on account of the swelling of the Black Irtysh, which flows into it from the E. The shores of the lake are marshy and overgrown with reeds. Besides the Black Irtysh, which has a length of 466 miles, it receives more than 10 streams of considerable size. The White or Lower Irtysh flows out of the lake at the north-western extremity, and is a deeper and fuller river than the Black Irtysh. The course of the latter is interrupted by falls and cataracts.

§ 4. Very extensive lakes occur in Africa. In lat. 20° 19′ and E. long. 22° is situated the recently discovered lake Ngami, which has hitherto been but imperfectly explored. It is supposed to be more than 70 miles long, and to be gradually lessening in dimensions. A large river, the Zouga, issues from its eastern extremity, where it is 200 yards wide; and is supposed to join the Limpopo. The elevation of the lake, as determined by its discoverers, Messrs. Livingstone, Oswell, and Murray, is 3285 feet above the sea.[1] Abyssinia has the large and beautiful lake of Dembea, or Tsana, situate in a spacious plain—the granary of the country—so high above the sea that spring is perpetual, though within the tropics. There are many other lakes in this great projecting promontory, so full of rivers, mountains, and forests, including the picturesque Lake Ashangi, embosomed in mountains, on the eastern edge of the plateau. Due W. of this, near the centre of the broad northern portion of the continent, is Lake Chad, almost the size of an inland sea, at an absolute elevation, according to Dr. Vogel's observations, of not more than 840 feet. Its area, and the extent of its basin, are imperfectly known; it receives many affluents from the unexplored highlands to the S. Other lakes of less magnitude are known to exist in these regions, and there are probably many more that are unknown. Salt-water lakes are numerous on the northern boundaries of the great lowland deserts, and many fine sheets of fresh water are found in the valleys and flat terraces of the Great and Little Atlas.

It is, however, in the equatorial part of the African interior where the largest of these sheets of inland water are found, and it is to the enterprise of English travellers during the last 15 years that we owe all that is at present known about them. The most southerly of these great lakes is Nyassa, discovered by Dr. Livingstone in 1859. It lies in a deep valley, trending N. and S., flanked by mountain ranges, and distant 300 miles from the eastern coast. Its length is about 250 miles, as far as at present known, but the northern extremity has not yet been traced. In some parts it is supposed to have a width of 60 miles, and its depth is very great; Mr. Young, the leader of the Livingstone Search Expedition, in 1867, found no bottom in one part with a line of 40 fathoms. The waters are clear, and of a deep blue colour, and abound in fish. In the dry season (July to December) the S.E. breeze blows with prodigious force up the lake, creating heavy waves and making its navigation dangerous. Lofty rocky headlands diversify the shore scenery, and between them are lovely bays, fringed with sandy beaches. The lake receives the drainage of the surrounding mountain slopes, and has its outlet at the southern end by the River Shiré, a tributary of the Zambesi. The mean elevation of its surface is 1522 feet above the sea. About 360 miles to the N.W.

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[1] 'Journal of Geographical Society of London,' vol. xx. p. 143.

of Nyassa lies Lake Tanganyika, discovered by Captains Burton and Speke in 1858. Less is at present known of this great fresh-water sea than of Nyassa, to which it is similar in its physical configuration, lying N. and S. in a deep valley hemmed in by highlands: it is, however, much larger. In 1867-8 Dr. Livingstone discovered a chain of smaller lakes at the south-western end of Tanganyika, varying from 20 to 50 miles each in length. N. of Tanganyika lies the vast expanse of Albert Nyanza, discovered by Sir Samuel Baker and his lady in 1864. At the point where the travellers first beheld this enormous sheet of water from a high cliff on its eastern shore, it appeared to be about 60 miles wide; but farther S. it was evidently broader, and its limits in that direction are at present unknown. At its northern extremity the Nile issues, and within 30 miles of the outlet the Albert receives the drainage of another large lake, the Victoria Nyanza of Speke, the southern end of which he discovered in 1858, and which he again saw in 1862 on the expedition in which he was accompanied by Captain Grant. The Victoria Nyanza, according to Speke, is 160 miles in length, and of great but unknown breadth. It lies at a much higher elevation than the Albert Lake, being 3740 feet above the sea-level, as compared with 2720, the altitude given to the Albert by Sir S. Baker, and its surplus waters flow N.W. into the lower lake by a river upwards of 200 miles in length, flowing in the latter part of its course with great rapidity, and finally leaping in a magnificent cascade to the level of the Albert, a few miles above its junction with the Lake. If the Albert Nyanza, the Tanganyika, and the Chambeze lakes, recently discovered by Livingstone, be really connected, as they are supposed to be, they will form a chain of lakes 840 miles in length. Thus it appears that in the centre of the torrid zone of the most torrid of continents, a system of fresh-water lakes exists, little inferior to that of the Laurentian lakes of North America, hitherto considered by far the largest on the globe. Being surrounded by healthy highlands and fertile plateaus, and rendered accessible by the Nile, they afford unexpectedly means of opening up and developing the resources of the vast interior of the African continent.

§ 5. A very large portion of North America is covered with fresh water; the five principal lakes—Superior, Huron, Michigan, Erie, and Ontario—with some of their dependents, probably cover an area of 94,000 square miles; that of Lake Superior alone, 32,000, which is only 1800 square miles less than the whole of England. Previous to the discovery of the lakes of equatorial Africa, the American lakes were held to contain two-thirds of all the fresh-water deposits on the globe. The altitude of these lakes shows the slope of the continent; the absolute elevation of Lake Superior is

628 feet; Lake Huron is 44 feet lower; Lake Erie, 19 feet lower than the Huron; and Lake Ontario is 333 feet below the level of Erie. The river Niagara, which unites the two last-named lakes, is 33½ miles long, and in that distance it descends from the height of 565 feet to that of 232 feet above the sea-level; but the upper part of its course is navigable. The height of the cascade of Niagara is 162 feet on the American side of the central island, and 1125 feet wide. On the Canadian side the fall is 149 feet high, and 2100 feet wide — the most magnificent sheet of falling water known, though many are higher. The river St. Lawrence, which drains the whole, slopes 234 feet between the bottom of the cascade and the sea. The bottom of Lake Superior is 300 feet, and that of Ontario 268 feet, below the surface of the Atlantic, affording another instance of deep indentation in the solid matter of the globe. Some lakes are decreasing in magnitude, though the contrary seems to be the case in America; between the years 1825 and 1838 Ontario rose nearly seven feet; and, according to the American engineers, Lake Erie had gained several feet in the same time. Lake Huron is said to be the focus of peculiar electrical phenomena, as thunder is constantly heard in one of its bays. The lakes N. of this group are innumerable; the whole country, to the Arctic Ocean, is covered with sheets of water. Lake Winnipeg, Reindeer Lake, Slave Lake, and some others, may be regarded as the chief members of separate groups or basins, each embracing a wide extent of almost unexplored country. There are also many lakes on each side of the Rocky Mountains: one of the most remarkable is the Great Salt Lake, on the plateau of the Great Basin between the Wahsatch Mountains and the Sierra Nevada of North America, whose surface has an elevation of 4290 feet above the level of the sea; it has several islands, its waters contain 22 per cent. of salts, chiefly muriate of soda, and its circuit is little less than 300 miles: the neighbouring Lake of Utah (4790 feet) is fresh, and empties itself into the Great Salt Lake by a river called the Jordan. In Mexico there are six or seven lakes of considerable size, though not to be compared with those in North America.

There are many sheets of water in Central America, though only one is of any magnitude, the Lake of Nicaragua, in the province of that name, about 100 miles from the sea, which communicates with the Gulf of Mexico by the river of San Juan.

In Central America the Andes are interrupted by plains and mere hills on the Isthmus of Tehuantepec and of Nicaragua, on each side of which there is a series of lakes and rivers, which, aided by canals, might form a water-communication between the Atlantic and Pacific Oceans. In the former, the line proposed would connect the River Goatzacoalcos, on the Gulf of Mexico, with the Bay of Tehuantepec, in the Pacific. In the Isthmus of Nicaragua, the Gulf of San Juanwould be connected by the river of that name, and the chain of lakes of Nicaragua and Leon, with the Bay of Realejo or the Gulf of Fonseca, with the Gulf of Costa Rica. Here the highest level necessary would be 212 feet above the Pacific, and of easy excavation; and the lake, situate in an extensive plain, and at an elevation of 125½ feet above the sea, is deep enough for vessels of considerable size.[1]

A range of lakes goes along the eastern base of the Andes, but the greater part of them are mere lagoons or marshes, some very large, which inundate the country to a great extent in the time of the tropical rains. There appears to be a deep hollow in the surface of the earth at the part where Bolivia, Brazil, and Paraguay meet, in which lies the lake Xarayos, extending on each side of the river Paraguay; but, like many South American lakes, it is not permanent, being alternately inundated and dry, or a marsh. Its inundations cover 36,000 square miles. Salt and fresh water lakes are numerous on the plains of La Plata, and near the Andes in Patagonia, resembling in this respect those in high northern latitudes, though on a smaller scale.

In the elevated mountain-valleys and table-lands of the Andes there are many small lakes of the purest blue and green colours, intensely cold, some being near the line of perpetual congelation. They are generally of considerable depth. The great fresh-water lake of Titicaca, however, in the Bolivian Andes, has an area of 2225 geographical square miles, and is more than 120 fathoms deep in many places, surrounded by splendid scenery. Though 12,846 feet above the level of the Pacific, and consequently higher than the Peak of Teneriffe, it contains several species of fish; its shores are cultivated, producing corn, barley, potatoes, and even Indian corn; and peopled by a large aboriginal population, inhabiting towns and villages. Numerous vestiges of Peruvian civilization are everywhere to be met with; and in the island from which it derives its name, and where tradition places the origin of the last Inca dynasty, numerous specimens of Peruvian architecture still exist. It receives several rivers from either branch of the Andes, but has only one exit, the river Desaguadero, the waters of which are lost by evaporation and infiltration in the sandy soil through which it flows, and in its terminal lake or marsh of Aullagas.[1]

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[1] The reader is referred to a paper published by Admiral FitzRoy in the 20th vol. of the Journal of the Geographical Society, for a lucid description and review of the different projected canals and routes across the American isthmus, viz., by the lake Nicaragua, the river of Goatzacoalcos, and the isthmuses of Panamá and Darien.

The limpid transparency of the water in lakes, especially in mountainous countries, is remarkable; minute objects are visible at the bottom through many fathoms of water. The vivid green tints so often observed in Alpine lakes may be produced by vegetable dyes dissolved in the water, though chemical analysis has not detected them.

Lakes, being the sources of some of the largest rivers, are of great importance for inland navigation as well as for irrigation; while, by the constant evaporation at their surface, they maintain the supply of humidity in the atmosphere so essential to vegetation.

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[1] See Pentland's map of the lake of Titicaca, published at the Hyd. Office in 1847.

CHAPTER XXIII.

ATMOSPHERIC PHENOMENA.

§ 1. Nature of the atmosphere; temperature of the earth's surface; radiation of heat; mean temperature; foci of maximum cold; atmospheric thermal equator—its temperature, mean and absolute; isothermal lines. § 2. Climates—continental, insular, and extreme; stability of climate; decrease of heat in altitude; line of perpetual snow. § 3. Density of the atmosphere; the barometer; measurement of heights; variations in density, and their causes; horary variations; independent effect of the dry and aqueous atmospheres; mean height of barometer in different latitudes; depression in the Antarctic Ocean, and in Eastern Siberia. § 4. Currents of the atmosphere; barometric waves; the trade-winds; monsoons. § 5. Hurricanes; the laws of their motion; their effect on the barometer; how to steer clear of them; the storm-wave; storm-currents; arched squalls; tornadoes; whirlwinds; water-spouts.

§ 1. THE atmosphere completely envelopes the earth to the height of certainly 100, and probably 200 or 300, miles; it bulges at the equator, and is flattened at the poles, in consequence of the diurnal rotation. It is a mixture of water in an invisible state and of air, but the air is not homogeneous: in 100 parts, 79 consist of nitrogen gas, and 21 of oxygen, the latter the source of combustion and animal heat, and 0·45 of water. Besides these, there is a small quantity of carbonic acid gas, varying from 3 to 5 ten-thousandths, which is sufficient to supply all the vegetation on the earth with wood and leaves, and a very minute proportion of ammoniacal gas.[1] Ozone is also a constituent of the atmosphere; it was discovered in 1848 by Professor Schönbein, of Basle. Ozone is a form of oxygen. It is produced by the passage of electricity through the air, or by the action of phosphorus on damp air. Oxygen may be transformed into ozone by the electric machine, and is constantly being produced by the electricity in the atmosphere, and especially by lightning during thunderstorms. The peculiar smell produced when objects are struck by lightning is owing to ozone. It is a great purifier of the air, uniting with the gases arising from decaying organic matter, and depriving them of their hurtful qualities. It is more abundant on the sea-coast than inland; on the W. than on the E. of Britain; on elevated than in low situations; with S.W. than with N.E. winds; in the country than in towns; on the windward than on the leeward side of towns. In our own country, it is most abundant from February to June, and least from July to January. It reaches its maximum in May, and its minimum in November. The nitrogen and oxygen of the air are only in a state of unchemical moisture and not of chemical combination. This fact is proved in various ways, one of the most striking being the circumstance that water absorbs more oxygen from the air than nitrogen, the amount of the two gases found in water being in exact proportion to the absorptive power of that fluid for each of them separately. If air were a chemical compound, the ratio of the mixed gases absorbed by the water would be preserved. Exhalations of various kinds ascend into the air, such as those which produce miasmata, but they are in quantities too minute to be detected by chemical analysis, so that the atmosphere is found to be of the same composition at all heights above the sea hitherto attained. In addition to this, it may be stated that the property possessed by gases of readily mixing with each other without regard to their respective specific gravities is a benign provision for preventing the accumulation of injurious exhalations. Thus the carbonic acid arising from the decay of organized substance, although half as heavy again as atmospheric air, diffuses into the higher regions of the atmosphere with great rapidity.

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[1] The researches of M. Ville show that the quantity of ammoniacal vapour in the air is so very minute as to exercise no influence, as was supposed by Liebig, on vegetation. M. Lewy has found that in some situations, as at Bogota, the proportion of carbonic acid gas varies with the seasons: thus, in 11 months out of the 12, the air contains the ordinary quantity, from $\frac{3}{10000}$ to $\frac{5}{10000}$ of its volume, whereas in September this proportion increases to $\frac{47}{10000}$, a circumstance quite inexplicable in the present state of meteorology.

The temperature of the earth's surface and the phenomena of the atmosphere depend upon the revolution and rotation of the globe, which successively expose all the parts of it, and the air which surrounds it, to a perpetual variation of the gravitating forces of the two great luminaries, and to annual and diurnal vicissitudes of solar heat. Atmospheric phenomena are consequently periodical and connected with one another, and their harmony and the regularity of the laws which govern them become the more evident in proportion as the mean values of their vicissitudes are determined from simultaneous observations made over widely extended tracts of the globe. The fickleness of the wind and weather is proverbial; but as nearly the same quantity of heat is annually received from the sun, and annually radiated into space, it follows that all climates on the earth are stable, and that their changes, like the perturbations of the planets, are limited and accomplished in fixed cycles, whose periods are still in many instances unknown. It is possible, however, that the earth and air may be affected by secular variations of temperature during the progress of the solar system through space, or from periodical changes in the sun's light and heat, similar to those which take place in many of the fixed stars. No doubt the spots on the sun must act upon the oxygen of the atmosphere, since they have so remarkable an influence on terrestrial magnetism; besides, they must occasion periodical variations both in the light and heat of the sun. The secular variation in the moon's mean distance will no doubt alter the amount of her attractive force, though probably by a quantity inappreciable in the aërial tides; at all events, variations arising from such circumstances could only become perceptible after many ages.

From experiments made by M. Peltier it appears that, if the absolute quantity of heat annually received by the earth were equally dispersed over its surface, it would, in the course of a year, melt a stratum of ice 46 feet deep enveloping the whole globe. It is evident that, if so great a quantity of heat had been continually accumulated in the earth, instead of being radiated into space, it would have been transmitted through the surface to the poles, where it would have melted the ice, and the torrid zone, if not the whole globe, would by this time have been uninhabitable. In fact, every surface absorbs and radiates heat at the same time, and the power of radiation is always equal to the power of absorption; for, under the same circumstances, bodies which become soon warm also cool rapidly; and the earth, as a whole, is under the same law as the bodies at its surface.

Oxygen and nitrogen are the most permeable of all gases to radiant heat; hence our atmosphere readily transmits solar heat. The presence of vapour, however, moderates the effects of radiation.

According to Professor Tyndall, so enormous is the absorbent power of aqueous vapour, that 10 per cent. of the terrestrial radiation is stopped within 10 feet above the surface of the ground in England, and were the aqueous vapour which floats in our atmosphere removed for one summer night, every plant would be destroyed by the freezing temperature.

Although part of the heat received from the sun in summer is radiated back again, by far the greater part sinks into the earth's surface, and tempers the severity of the winter's cold while passing through the atmosphere into the ethereal regions.

The earth is about 3,000,000 of miles nearer to the sun in winter than in summer, but the rays strike the northern hemisphere more obliquely in winter than in the other half of the year; and Professor Secchi has shown that on that account the atmosphere absorbs more of the sun's heat in winter than in summer. At Rome, in the finest season of the year, he found that, when the sun is in the zenith, the atmosphere absorbs one-fourth of the heat during the vertical transit of his rays; when they fall at the distance of 60 degrees from the zenith, the loss is one-half, and continues to be very rapid as the obliquity increases. Thus the difference between the summer and winter temperature depends chiefly on the absorbing power of the atmosphere. The Professor observes that the absorbed heat is not lost, but supplies the greater part of that which is radiated into space.[1]

Sir John Herschel has shown that the elliptical form of the earth's orbit has but a trifling share in producing the variation of temperature corresponding to the difference of seasons; for although in one-half of its orbit the earth is nearer the sun than in the other half, its motion is so much more rapid in the former than in the latter, that it is exposed for a shorter time to the sun's influence: thus a compensation takes place, and an equal distribution of light and heat is accorded to both hemispheres.

But on account of the present position of the earth's orbit, the *direct* heating power of the sun in summer is greater by nearly one-eighteenth of its whole intensity in the southern than in the northern hemisphere, in equal latitudes and under equal circumstances of exposure; for that reason the sufferings of travellers in the southern deserts are much more intolerable than in the northern. In the account of the exploring expedition into the interior of Australia, Captain Sturt mentions that "the ground was almost a molten surface; and if a match accidently fell on it, it immediately ignited." Sir John Herschel has observed the temperature of the surface-soil in South Africa as high as 159° Fahrenheit.[2] By direct experiments made at Rome, Professor Secchi found that a thermometer exposed to the sun in an open field, and slightly covered with earth, rose to 150°·6 Fahrenheit at half past one o'clock in the month of July, which differs only by 8°·4 from that of South Africa.

Diurnal variations of heat are perceptible only to a small distance below the surface of the ground, because the earth is a bad conductor: the annual influence of the sun penetrates much farther; at the equator, where the heat is greatest, it descends deeper than

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[1] The following are the results of Professor Secchi's experiments:—

Sun's zenith distances	0°	20°	40°	60°	80°
Remaining quantity of solar heat transmitted through the atmosphere at Rome	0·72	0·70	0·64	0·51	0·16

[2] Sir J. Herschel's Outlines of Astronomy, p. 218, 1849.

elsewhere, with a diminishing intensity; but there, and everywhere throughout the globe, there is a stratum, at a depth varying from 40 to 100 feet below the surface of the ground, where the temperature never varies, and is nearly the same as the mean temperature of the country. This zone, unaffected by the sun's heat from above, or by the internal heat from below, serves as an origin whence the effects of solar heat are estimated on one hand, and the internal temperature of the globe on the other. Below it the heat of the earth increases, as already mentioned, at the rate of one degree of Fahrenheit's thermometer for every 50 feet of perpendicular depth; were it to continue increasing at that rate, every substance would be in a state of fusion at the depth of 21 miles; hitherto, however, the experiments in mines and artesian wells, whence the earth's temperature below the constant stratum is ascertained, have not been extended below 1700 feet.[1]

M. Elie de Beaumont has estimated by the theory of Fourier, and from the observations of M. Arago, that the quantity of central heat which reaches the surface of the earth is capable, in the course of a year, of melting a shell of ice a quarter of an inch thick[1] covering the globe.

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[1] The protuberant matter at the earth's equator occasions a nutation in the lunar orbit, and the action of the sun and moon on that protuberant matter produces those inequalities in the earth's rotation known as the Luni-Solar Nutation and Precession. (See Connexion of Physical Sciences, sections 5 and 11.) These inequalities have been computed on the hypothesis of the earth being a solid mass. Mr. Hopkins has found that the result would be the same if the earth consisted of a solid shell, enclosing a nucleus of liquid fire, provided the shell were from 800 to 1000 miles in thickness. According to the actual increase of internal heat, the earth must be in fusion at the depth of 21 miles, a circumstance equally inconsistent with the preceding result, and with the amount of precession. However, the temperature at which fusion takes place is probably different at different depths on account of the enormous pressure. (See Connexion of Physical Sciences, p. 83.) Now Mr. Hopkins has recently shown that, if the pressure has no effect in increasing the temperature of fusion, the existing temperature cannot be due to original central heat, but if it does affect it, then, along with the increasing tendency of heat to prevent solidification as the depth increases, there would be an increasing tendency to promote it, by rendering the mass fusible at a higher temperature. According as one or other of these tendencies predominates, different cases occur; consequently the internal state of the globe may be determined by experiments on the effect of high pressure on the temperature of fusion. Were the earth composed of a solid shell filled with fluid matter, the lava would stand at the same height in all volcanoes, which it does not; and the same would happen if the globe had a solid nucleus from high pressure, and a solid crust from refrigeration, with matter between, which is one of the possible cases arising from Mr. Hopkins's investigation. He shows, however, that from various circumstances the solid nucleus and the solid crust may be so united at intervals as to divide the molten matter into basins or seas of lava, which may be at different levels below the surface, a state that agrees better than any other with the phenomena of volcanoes. Professor Belli, of Pavia, thinks that in different volcanoes the lava stands at equal heights.

The superficial temperature of the earth is great at the equator, it decreases gradually towards the poles, and is an exact mean between the two at the 45th parallel of latitude; but a multitude of causes disturb this law, even between the tropics. It is affected chiefly by the unequal distribution of land and water, by the height above the sea, by the nature of the soil, and by vegetation; so that a line drawn on a map through all the places where the mean temperature of the earth is the same would be very far from coinciding with the parallels of latitude, but would approximate more to them as it approaches the equator. Between the tropics the temperature of the earth's surface is greater in the interior of continents than on the sea-coasts and islands, and in the interior of Africa it is greater than in any other part of the globe.

Temperature depends upon the property all bodies possess, more or less, of perpetually absorbing and emitting or radiating heat. When the interchange is equal, the temperature of a substance remains the same; but when the radiation exceeds the absorption, it becomes colder, and *vice versâ*. The temperature of the air is certainly raised by the passage of the solar heat through it, because it absorbs one-third of it before reaching the earth, but it is chiefly warmed by heat transmitted and radiated from the earth. The radiation is abundant when the sky is still, clear, and blue, but clouds intercept it; so that a thermometer rises in cloudy weather, and sinks when the air becomes clear and calm; even a slight mist diminishes radiation from the earth, because it returns as much heat as it receives. The temperature of the air is subject to such irregularities from these circumstances, from the difference in the radiating powers of the bodies at the surface of the globe, that it is necessary to find, by experiment, the mean or average warmth of the day, month, and year, at a great variety of places, in order to have a standard by which the temperature in different parallels of latitude may be compared.

An approximation to the mean diurnal temperature of the air, at any place, is equal to half the sum of the greatest and least heights of the thermometer during 24 hours; and as the height of the thermometer is twice, in the course of that time, equal to the mean temperature of the place of observation, it might seem easy to obtain its value; yet that is not the case, for a small error in observation produces a very great one in such minute quantities, so that accuracy can only be attained from the average of a great number of observations, by which the errors, sometimes in excess and sometimes in defect, neutralize or balance each other. The mean value of quantities is a powerful aid to the imperfections of our nature in arriving at truth in physical inquiries, and in none more than in atmospheric phenomena. Almost all the certain knowledge man has acquired with regard to the density and temperature of the air, winds, rain, &c. has been acquired by that method.

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[1] Annales des Sciences géologiques, par M. Rivière, 1842.

The mean temperature of any one month at the same place differs from one year to another, but the mean temperature of the whole year remains nearly the same, especially when the average of a great number of years is taken into consideration: for although the temperature in any one place may be subject to very great variations, yet it never deviates more than a few degrees from its mean state.[1]

The motion of the sun in the ecliptic occasions perpetual variations in the length of the day, and in the direction of his rays with regard to the earth; yet, as the cause is periodic, the mean annual temperature from the sun's motion alone must be constant in each parallel of latitude. For it is evident that the accumulation of heat in the long days in summer, which is but little diminished by radiation during the short nights, is balanced by the small quantity of heat received during the short days of winter and its radiation in the long frosty and clear nights.[2] Were the different points of the globe everywhere on a level with the surface of the sea, and of uniform substance, so as to absorb and radiate heat equally, the mean heat of the sun would be regularly distributed over its surface in zones of equal annual temperature parallel to the equator, and would decrease regularly to each pole. The distribution of heat, however, in the same parallel is very irregular in all latitudes, even between the tropics, from the inequalities in the level and nature of the surface of the earth, so that lines drawn on a map through all places having the same mean annual temperature are nearly parallel to the equator only between the tropics: in all other latitudes they deviate greatly from it, and from one another.[1] Radiation is the principal modifying cause of temperature; hence the heat of the air is most powerfully modified by the ocean, which occupies three times as much of the surface of the globe as the land, and is more uniform in its surface, and also in its radiating power. Its volume is 400 times greater than that of the atmosphere, and the evaporation over its surface is so great that, were it not restored, it would depress its level about five feet annually; the quantity of heat absorbed in this manner, and again liberated during rain, is enormous. On the land, the difference in the radiating force of the mountains and table-lands from that of the plains—of deserts from grounds covered with rich vegetation—of wet land from dry, is the most general cause of variation.

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[1] The mean of any number of unequal quantities is equal to their sum divided by their number. To ascertain the mean annual temperature at any place accurately, the mean of a great number of years must be taken.

[2] The warmest time of the day is between two and three in the afternoon; the coldest, shortly before sunrise; but on mountain-tops, where the effects of radiation from the ground are comparatively small, the time of greatest warmth depends on the direct rays of the sun, and is therefore a little before noon. The maximum annual temperature occurs about the middle of July in the northern hemisphere, the minimum is in January; so that the former takes place some time after the summer solstice, because the earth absorbs more heat than it radiates during that interval, and for the contrary reason the greatest cold is some time after the winter solstice; the mean takes place in April and October.

There are two points in the northern hemisphere, both in the 80th parallel of latitude, where the cold is more intense than in any other part of the globe with which we are acquainted. One N. of Canada, in 80° N. lat. and 100° W. long., has a mean temperature of − 3°·5 of Fahrenheit; while at the Siberian point, in 95° E. long., the mean temperature of the air is +1°; consequently it is four and a half degrees warmer than that N. of Canada—a difference that has an influence even to the equator, where the mean temperature of the air is different in different longitudes. Sir David Brewster has computed that the mean temperature of the North Pole of the earth's rotation is not under 5° of Fahrenheit, and may be even 17°, supposing the ocean to extend so far, which there is every reason to believe that it does; but M. Arago's estimate on the hypothesis of there being land at the North Pole makes the cold much greater, for land increases the cold by abstracting heat from the air in high latitudes, and augments the heat by radiation in low latitudes.

The line of the maximum temperature of the atmosphere, or the atmospheric thermal equator, which cuts the terrestrial equator in the meridians of Tahiti and Singapore, passing through the Pacific in its southern course, and through the Atlantic in its northern, has a mean temperature of 83°·84 of Fahrenheit. But by the comparison of many observations the mean equatorial temperature of the air is 82°·94 in Asia, 85°·10 in Africa, and 80°·96 in America: thus it appears that tropical Africa is the hottest region on earth. Moreover, the atmosphere in the tropical zone of the Pacific, when free from currents, is two degrees and a quarter warmer than the corresponding zone in the Atlantic, which is 82°·40. Local circumstances increase both heat and cold immensely; in the Nubian Desert, for example, a heat of 150° of Fahrenheit in the sun, and 130° in the shade, has been observed. Perhaps the greatest degree of heat on record was that experienced by Captain Griffiths near the Euphrates, where the thermometer stood at 156° in the sun, and 132° in the shade. In December, 1738, at Kiringa, in Siberia, Gmelin is said to have experienced cold of — 80°; the gentlest breeze would have rendered that cold fatal by the rapid abstraction of heat from the body. In December, 1866, at Nulato, a post of the Russian Fur Company, on the Lower Yukon, the thermometer fell to — 58° Fahr., 90° below freezing.

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[1] Lines drawn on a map or globe through all places where the mean annual temperature is the same are called *isothermal lines.*

On account of the great extent of ocean, the isothermal lines in the southern hemisphere coincide more nearly with the parallels of latitude than in the northern. In the Pacific Ocean the only flexure is occasioned by the cold of the S. polar current, which flows along the western coast of the American continent. In the northern hemisphere the predominance of land and its frequent alternations with water, the prevalence of particular winds, irregularities of the surface, and the difference in the temperature of the points of maximum cold, cause the isothermal lines to deviate more from the parallels of latitude. They make two deep bends northward, one in the Northern Atlantic and another in the N.W. of America, and at last they separate into two parts, and encircle the points of maximum cold.

Professor Dove has shown that, in consequence of the excess of land in the northern hemisphere, and the difference in the effect produced by the sun's heat according as it falls on a solid or liquid surface, there is an annual variation in the aggregate mean temperature at the surface of the earth, whose maximum takes place during the sun's northern declination, and its minimum during its southern.[1]

§ 2. Places having the same mean annual temperature often differ materially in climate: in some the winters are mild and the summers cool, whereas in others the extremes of heat and cold prevail; England is an example of the first; Quebec, St. Petersburg, and the Arctic regions, are instances of the second. The solar heat penetrates more abundantly and deeper into the sea than into the land; in winter the sea preserves a considerable portion of that which it receives in summer, and from its saltness does not freeze so soon as fresh water; hence the ocean is not liable to the same changes of temperature as the land, and by imparting its heat to the winds it diminishes the severity of the climate on the coasts and in islands, which are never subject to such extremes of temperature as are experienced in the interior of continents. The difference between the influence of sea and land is strikingly exemplified in the high latitudes of the two hemispheres. In consequence of the unbounded extent of the ocean in the south, the air is so mild and moist that a rich vegetation covers the ground, while in the corresponding latitudes in the N. the country is barren from the excess of land towards the Polar Ocean, which renders the air dry and cold. A superabundance of land in the equatorial regions, on the contrary, raises the temperature, while the sea tempers it.

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[1] For example, Professor Dove has found that the mean temperature of December, January, and February, at Toronto, in Canada, added to the mean temperature of the same months at Hobart Town, in Tasmania, exceeds the sum of the mean temperature of June, July, and August, at the same places, added together, by 22°·7 of Fahrenheit. Similar results, though varying in amount, were obtained for many corresponding stations in the two hemispheres, which establishes the law given in the text.

Professor Dove has shown from a comparison of observations, that Northern and Central Asia have what may be termed a true continental climate both in summer and in winter—that is to say, a hot summer and cold winter; that Europe has a true insular or sea climate in both seasons, the summers being cool and the winters mild; and that in North America the climate is inclined to be continental in winter and insular in summer. The extremes of temperature in the year are greater in Central Asia than in North America, and greater in North America than in Europe, and that difference increases everywhere with the latitude. In Guiana, within the tropics, the difference between the hottest and coldest months in the year is only 2°·2 of Fahrenheit, in the temperate zone it varies from 20° to 50°, and at Yakutsk, in Siberia, is 106°. Even in places which have the same latitude as in Northern Asia, compared with others in Europe or North America, the difference is very great. At Quebec the summers are as warm as those in Paris, and grapes sometimes ripen in the open air, yet the winters are as severe as those in St. Petersburg. In short, lines drawn on a map through places having the same mean summer or winter temperature are neither parallel to one another nor to the isothermal or isogeothermal lines, and they differ still more from the parallels of latitude.[1]

Observations tend to prove that all the climates on the earth are stable, and have remained so from the remotest historical periods;

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[1] In the same manner as isothermal lines are supposed to pass through all parts of the globe where the mean temperature of the air is the same, so the isogeothermal lines are supposed to pass through all places where the mean heat of the ground is the same: the isothermal lines are supposed to be drawn though all places having the same mean summer temperature; and the isochimenal lines pass through all places where the mean winter temperature is the same. The practice of representing to the eye these lines on a map or terrestrial globe is of great use in following and understanding the complicated phenomena of temperature and magnetism.

and that their vicissitudes are only oscillations of greater or less extent, which vanish in the mean annual temperature of a sufficient number of years. There may be a succession of cold summers and mild winters, but in some other country the contrary takes place; the distribution of heat may vary from a variety of circumstances, but the absolute quantity gained and lost by the whole earth in the course of a year is invariably the same.[1]

Since the air receives its warmth chiefly from the earth, its temperature diminishes with the height so rapidly that at a very small elevation the cold becomes excessive, as the perpetual snow on the mountain-tops clearly shows. Besides, as the warm air ascends, it expands, and, its capacity for heat being increased, more is absorbed, which gradually diminishes the sensible heat shown by the thermometer; the decrease is nearly at the rate of a degree of Fahrenheit's thermometer for every 300 feet. By computations founded on the capacity of the air for heat, and absorption of the solar light in the atmosphere, Fourier has estimated the temperature of the ethereal regions to be −50° of Fahrenheit, while M. Pouillet makes −220° from direct experiments on the radiation of terrestrial heat into a clear blue sky during the night. Sir John Herschel supposes it to be about −239°.

§ 3. The atmosphere, being a heavy and elastic fluid, decreases in density upwards, according to a determinate law, so rapidly, that three-fourths of the whole air which constitutes it are within four miles of the earth, and all the phenomena perceptible to us—as clouds, rain, snow, and thunder—occur within that limit. The air even on the tops of mountains is so rare as to diminish the intensity of sound, to affect respiration, and to occasion a loss of muscular strength in man and animals.[2]

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[1] According to the researches of M. Arago, the climate of France has not altered since a century before the Christian era, that is, in a period of nearly 2000 years; and M. Dureau de la Malle has arrived at the conclusion that the climate of Italy has not varied from the time of Cato the Censor, who died 147 years before Christ, to the present time, or in 20 centuries, by comparing the times of ripening of different vegetables and plants, the periods of the vintage, and of the harvest, as given in the writings of Varro, Columella, &c., with the ripenings and harvests as they take place at present, and in the same localities.—Dureau de la Malle sur la Climatologie, &c., de l'Italie, &c., Paris, 1850, 8vo. It has been established by actual observation of the thermometer that the climate of Central Italy has not varied since the time of Galileo, 220 years ago.

[2] If the heights above the earth increase by equal quantities, as a foot or a mile, the densities of the strata of air, or the heights of the barometer which are proportional to them, will decrease in geometrical progression: for example, if the height of the barometer at the level of the sea be 29·922 inches, it will be 14·961 inches at the height of 18,000 feet, or one-half as great; it will be one-fourth as great at the height of 36,000 feet, one-eighth at the height of 54,000 feet and so on.

Since the space in the top of the tube of a barometer is a vacuum, the column of mercury is suspended in the tube by the pressure of the atmosphere on the surface of the mercury in the cistern: hence every variation in the density or height of the atmosphere occasions a corresponding rise or fall in the barometric column. The actual mean pressure of the atmosphere at the level of the sea is between 14½ and 15 pounds on the square inch; hence the pressure on the whole earth is enormous. It is equal to the weight of a solid globe of lead 60 miles in diameter.

The decrease in the density of the air affords an accurate method of finding the height of mountains above the level of the sea, which would be very simple, were it not for changes of temperature and moisture which alter the amount of the pressure and interfere with the regularity of the law of its decrease. But as the heat of the air, as before stated, diminishes with the height above the earth at the rate of one degree of Fahrenheit's thermometer for every 300 feet, tables are constructed by the aid of which heights may be determined with considerable accuracy. In consequence also of diminished pressure, water boils at a lower temperature on mountain-tops than at the level of the sea, which affords another method, although less exact, of ascertaining heights.[1]

By the annual and diurnal revolutions of the earth, each column of air is alternately exposed to the heat and cold of summer and winter, of day and night; and also to variations occasioned by the attraction of the moon, producing tides similar to those of the ocean, although in a less marked degree. These lunar tides ebb and flow twice during a lunation; their extent has been satisfactorily determined at stations within the tropics. Variations to a much larger extent are produced by the action of the sun's heat on the atmosphere; they accomplish their rise and fall twice in the 24 hours, and are entirely due to the effects of temperature on the air and the moisture contained in it, by which, according to Mr. Dove's researches, independent pressures on the mercurial column in the barometer are occasioned.[1]

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[1] A very ingenious little instrument, called the Aneroid Barometer, has been invented by M. Vidi, of Paris; which, at the same time that it forms an exact and very portable *weather*-glass in the common acceptation of that term, may be employed with considerable accuracy in ascertaining differences of level. Although not to be compared, as an instrument of precision, with the ordinary mercurial barometer, it is infinitely more portable, and gives with promptitude and accuracy small differences of pressure; it will be found, under proper precautions, and comparison from time to time with the mercurial barometer, a most useful companion to the traveller in mountain districts.

A friend of the author's tested it in the latter respect on some of our railways, and found that observations made with it carefully will give, on a line of 200 miles in extent (on the Great Western Railway, for instance, between London and Plymouth), the relative levels of the different stations within a very few feet. The observations can be made in a couple of minutes. The aneroid barometer is a very useful instrument to the geological and the botanical traveller.

A quantity of vapour is continually raised by the heat of the sun from the surface of the globe, which mixes in an invisible state with the dry air or gaseous part of the atmosphere. It is most abundant in the torrid zone, and, like the heat on which it depends, varies with the latitude, the season of the year, the time of the day, the elevation above the sea, and also with the nature of the soil, the land, and the water. There is no chemical combination between the aërial and aqueous atmospheres, they are merely mixed; and the diurnal variations arise from the superposition of two distinct diurnal oscillations, each going through its complete period in 24 hours; one taking place in the aërial atmosphere from the alternate heating and cooling of the air, which produce a flux and reflux over the point of observation; the other arising from the aqueous atmosphere, owing to the alternate production and destruction of vapour by the heat of the day and the cold of the night. The diurnal variations of the vapour have their maximum at or near the hottest hour of the day, and their minimum at or near the coldest, which is exactly the converse of the diurnal variations of the dry air. On the whole there are two maxima and two minima heights of the barometer in the course of 24 hours from the combinations of these, but in the interior of continents far from water, where the air is very dry, there ought to be one maximum and one minimum during that period according to this theory. That appears to be actually the case in some parts of Asiatic Siberia, and of the interior of North America during the winter season, when there is scarcely any aqueous vapour present in the atmosphere.

Between the tropics the barometer attains its greatest height at half-past nine in the morning; it then sinks till half-past four in the afternoon, after which it again rises and attains a second maximum at half-past ten in the evening; it then begins to fall till it reaches a second time its lowest point at half-past three in the morning. The mean difference in the height is 0·117 of an inch, which gradually decreases N. and S. Humboldt mentions that the diurnal variations of the barometric pressure are so regular between the tropics that the hour of the day may be inferred from the height of the mercury to within 15 or 16 minutes, and that it is undisturbed by rain, or earthquake, both on the coasts and at altitudes 13,000 feet above them. Among the results obtained at Kew from observations made during numerous voyages, it appears that between 5° and 10° N. latitude the range of the barometer is so small and so regular as to time, that a barometer may be verified in crossing that zone with perfect confidence. The mean height of the barometer between the tropics at the level of the sea is 30 inches with very little fluctuation, but, owing to the ascending currents of air from the heat of the earth, it is less under the equator than in temperate zones, and the decrease towards the equator is extremely regular. It attains a maximum in Western Europe between the parallels of 40° and 45°; in the North Atlantic the maximum is about the 30th parallel, and in the southern part of that ocean it is near the tropic of Capricorn; the amplitude of the oscillations decreases from the tropics to about the 70th parallel, where the diurnal variations cease. They are affected by the seasons, being greatest in summer and least in winter. It appears also that the fluctuations are the reverse on mountain-tops from what they are on the plains, and probably at a certain height they would cease altogether.[1] It is a singular fact, discovered during Sir James C. Ross's last voyage, that the mean height of the barometer is lower throughout the Antarctic Ocean and at Cape Horn than it is at the Cape of Good Hope or Valparaiso. It depends upon there being less air and more vapour in the southern than in the northern hemisphere. For the enormous quantity of vapour raised by evaporation from that vast expanse of ocean permanently expels a large portion of the atmosphere, just as steam expels air from a boiler, and that is proved by the mean height of the barometer being 30·1 between the equator and 78° 37′ N. lat., while its mean height in 70° S. lat. is only 29·0. Hence the depression observed by Sir James Ross. A similar depression near the sea of Okhotsk, in Eastern Siberia, is recorded by M. Ermann. But in this case it is the cold that condenses the vapour into clouds, heat is liberated, which swells out the superincumbent air and diminishes the pressure. A considerable amount of investigation has recently been given by Mr. Buchan, the Secretary of the Scottish Meteorological Society, to the question of the distribution of atmospheric pressure over the globe, during the different months of the year. He finds that in July, the lowest pressures are distributed over the continents, and the larger the continental mass the greater the depression, and that the high pressures are distributed over the oceans, between 50° N. and 50° S. lat., the highest pressures occurring in those parts of the ocean most completely enclosed by the continents. In January, on the contrary, the isobaric lines show a pressure above the average which is almost confined to the northern hemisphere, and is highest of all in Central and Northern Asia, while a low pressure prevails in the southern hemisphere and in the North Atlantic, having its greatest depression in Iceland. The mean annual atmospheric pressure shows two regions of high pressure passing round the earth in broad belts to the N. and S. of the equator. Between them is the tropical belt of low pressure, in the centre of which is a narrower belt of still lower pressure towards which the trade-winds blow. The regions of low pressure are round the poles, the most remarkable being that round the S. pole. From the registers of 100,000 observations, it is shown that the mean pressure diminishes from 29·740 inches, in lat. 45° to 50° S., to 28·960 inches, in lat. 75° to 80° S. The low pressures are the result either of high temperature, or of an excessive amount of vapour in the atmosphere. Ascending currents of air prevail in all regions of low pressure, and pour over in the upper currents of the atmosphere into the regions of high pressure.

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[1] The moon's orbit is very much elongated, so that her distance from the earth varies considerably, and consequently her attractive force. Moreover, her attraction varies with the rotation of the earth, which brings her twice in 24 hours in the meridian of any place, once in the superior and once in the inferior meridian; but her attractive action on the atmosphere is much inferior to that of the sun. The amount of the moon's attractive force on the atmosphere was first deduced by General Sabine (Phil. Trans. 1847 and 1852) from the observations made at the Colonial Observatories of St. Helena and Singapore, and found by him to be 0·570 of an inch in lat. 1° 3′, and 0·365 in 16°.

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[1] Mr. Pentland has, however, found within the tropics, in the Peru-Bolivian Andes, at elevations between 11,000 and 14,000 feet, the horary oscillations of the barometer as regular, and nearly as extensive, as on the level of the sea in the same latitude; they have also been found to observe the same regularity at still more elevated stations in the Himalayas, although the extent of the oscillation was less, owing possibly to the extra-tropical position of that region.

§ 4. Besides the small horary undulations, there are vast waves moving over the oceans and continents in separate and independent systems, being confined to local yet very extensive districts, always accompanied with continued rains or dry weather over wide tracts of country. By numerous barometrical observations made simultaneously in both hemispheres, the courses of several have been traced, some of which take 24, others 36 hours, to accomplish their rise and fall. One especially of these vast barometric waves, many hundreds of miles in breadth, has been traced over the greater part of Europe, and not its breadth only, but also the direction of its front and its velocity, have been clearly ascertained. The course of another wave has been made out from the Cape of Good Hope, through many intermediate stations, to the observatory at Toronto in Canada. Since every undulation has its perfect effect independently of the others, each one is marked by a change in the barometer, and may be beautifully represented by curved lines on paper, constructed from a series of observations. The general form of the curve shows the character of the principal wave, while small undulations in its outline mark the maxima and minima of the minor oscillations. Although, like all other waves, these in the atmosphere are but waving forms, in which there is no transfer of air, yet winds arise from them, and Sir John Herschel is of opinion that the crossing of two of these vast aërial waves, coming in different directions, may generate at the point of intersection those tremendous revolving storms, or hurricanes, which spread desolation far and wide.

The air expands and becomes lighter with heat, contracts and becomes heavier with cold, and, as there are 82 degrees of difference between the equatorial and polar temperature, the light warm air at the equator is constantly ascending to the upper regions of the atmosphere, and flowing N. and S. towards the poles, from whence the cold, dry, and consequently heavy air rushes to supply its place, since the same tendency to restore equilibrium exists in air as in water and other fluids. Now the winds from the poles blow in the upper regions of the atmosphere, and, as they have no rotary motion when they leave the poles, they are deflected from their meridional course by the continually increasing velocity of the earth's rotation as they approach to the equator. But these polar winds, being cold, dry, and heavy, sink down at the tropics and become surface winds; and as they still revolve slower than the corresponding parts of the earth at which they successively arrive, the bodies on its surface strike against them with the excess of their velocity, so that the wind, to a person who thinks himself at rest, blows in a direction contrary to that of the earth's rotation. For that reason a current from the N. becomes the N.E. trade-wind after arriving at the tropic of Cancer, and one from the S. becomes the S.E. trade-wind after leaving the tropic of Capricorn. These two winds continue their course, and, when they arrive at the equator, being highly rarefied, they probably rise, cross each other, and then each pursues its course as an upper current till they come to the tropics; and now being chilled in the higher regions, they sink down, cross again, and each flows along the surface to the poles, where there would be an accumulation of air if they did not cross and rise to the surface of the atmosphere to begin a new course.

It was shown that the easterly direction of the trade-winds is caused by currents of air coming along the surface of the globe with less rotary motion than the places they successively arrive at; on the contrary, the surface currents that flow from the tropics to the poles have a greater rotary motion than the latitudes they successively come to; therefore they become a N.W. wind in the southern hemisphere, and a S.W. wind in the northern; which are the prevailing winds in the extratropical latitudes. In fact, the difference of temperature puts the air in motion, and the direction of the resulting wind at every place depends upon the difference between the rotary motion of the wind and the rotary motion of the earth; the whole theory of the trade-winds depends upon these circumstances.

Thus, in each of the temperate, and in each of the torrid zones, there are two currents of wind, an upper and an under current, blowing contemporaneously in opposite directions. Wherever these currents cross there is a region of calms, because they balance or neutralize each other through a certain space and then go on. Hence there is a belt of calms a little N. of the equator, which girdles the earth with a mean breadth of six degrees: on each side of this are the trade-winds, of which the N.E. trade-wind is the narrowest, on account of the excess of land in the northern hemisphere: then come the calms of Cancer and Capricorn, or Doldrums of the sailors; then the extratropical winds; and lastly the polar calms.

That the winds cross one another in the calm belts there seems to be no doubt. For example, two winds proceed from the calm belt of Cancer that blow along the surface of the earth: one from its S. side in a steady breeze, which is the N.E. trade-wind; another wind comes from the N. side of the same belt of calms, which blows to the N.E., and forms the south-westerly winds so prevalent in the North Atlantic. They leave the calm belt loaded with vapour, which is precipitated as they pass into a colder zone, and they supply all the springs and rivers in the northern hemisphere with water. Now these S.W. winds do not obtain that enormous quantity of vapour while crossing the Atlantic, for they probably give by rain as much as they receive by evaporation, therefore it can only come from the southern hemisphere. The S.E. trade-winds carry the moisture evaporated from the great southern ocean to the equator; there they rise into the higher regions of the atmosphere, and blow as an upper current to the calm belt of Cancer; and now, being chilled, they sink down and come out from the N. side of the calm belt as the rainy S.W. winds of the extratropical northern hemisphere. The very same reasoning applies to the calm belt of Capricorn, the direction of the winds alone being different. Thus it has been considered that the winds in their circuits cross in the calm regions.

The polar calms where the winds cross are not points but spaces of considerable extent, whose existence is proved both by observations and theory, for Parry and Barrow found reasons during their voyages in the Arctic Circle to believe that there is a perpetual calm at the N. pole; Bellot also records the existence of a calm region in the frigid zone; and Professor J. H. Coffin, by a laborious investigation of the winds of the northern hemisphere, has determined the region of N. Polar calms to be situated in 84° N. lat. and 105° W. long.; consequently the pole of the winds coincides with the pole of maximum cold determined by Sir David Brewster, for the pole of maximum cold is no more a point than the pole of the winds, but an area of some extent. The great currents of air, like the oceanic rivers, or great currents of the sea, both unite in tempering the excess of heat in the tropics, and of cold in the polar and temperate regions.

Rain-dust has been most wonderfully the means of proving that the trade-winds after meeting at the equator rise up, cross, and continue their course as upper currents. A brick-red dust has frequently fallen in large quantities on ships in the Atlantic, especially about the Cape de Verd islands, which was supposed to be brought by the winds from the deserts of Africa; but specimens of it having been examined by Professor Ehrenberg, from the Cape de Verd islands, from Malta, Genoa, Lyons, and the Tyrol, he found that they all consisted of infusoria and organisms whose habitat is South America; and Captain Maury considers it "as an established fact, that there is a perpetual upper current of air from South America to North Africa, and that the volume of air which flows to the northward in these upper currents is nearly equal to the volume which flows to the southward with the N.E. trade-winds." Clouds carried by an upper current are frequently seen flying in a contrary direction to those nearer to the earth, and it is a well-known fact that the trade-winds have a limited vertical extent of about three miles, and that at a certain elevation, on the top of the Peak of Teneriffe for example, the wind blows in an entirely contrary direction from that prevailing at the same time at the level of the sea.[1]

Near the equator the trade-winds, N. and S. of it, so completely neutralize each other, that far at sea a candle burns without flickering. This zone of calms and light breezes, known as the *Variables*, is subject to heavy rains and violent thunder-storms. On account of the unequal distribution of land and water in the northern and southern hemispheres, the terrestrial equator is not the line of greatest heat, therefore the centre of the zone of equatorial calms in question does not coincide with it, but runs along the sixth parallel of N. latitude; however, it changes in position and extent with the declination of the sun. In summer it is found between the parallels of 8° and 14° of N. lat., and in spring it lies between 5° S. and 4° N. lat. In fact, the whole system, including the calm belts at the tropics, the trade-winds, and the zone of equatorial calms, follows the sun's motion in declination, moving backwards and forwards annually a thousand miles in latitude, nearly. In mid-ocean in the Atlantic, the *north trades* prevail between latitudes 9° and 30°, and in the Pacific between latitudes 9° and 26°; and the *south trades* in the Atlantic, between latitudes 4° N. and 22° S., and in the Pacific between latitudes 4° N. and 23½° S. These limits are, however, not stationary, but follow the sun, advancing northwards from January to June, and retreating southwards from July to December.

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[1] In the Atlantic the S.E. trade-wind blows with most regularity between 10° and 5°, and with most force between 10° and 15° S. lat.

The region of equatorial calms is a belt of about 4° or 5° in breadth, stretching across the Atlantic and the Pacific, generally parallel to the equator. It has a lower atmospheric pressure than the regions of the trades, and it is subject daily to heavy rains and thunderstorms. In the Indian Ocean this belt of calms wholly disappears during the S.W. monsoon.[1]

Thus, though the trade-winds extend to the 28th degree on each side of the equator, their limits vary considerably in different parts of the ocean, moving to the N. or S., according to the position of the sun; and in the Atlantic the N.E. trade-wind is less steady than the S.E. These perennial winds are known by recent observation to be less uniform in the Pacific than in the Atlantic; they only blow permanently over that portion between the Galapagos Archipelago, off the coast of America, and the Marquesas. In the Indian Ocean the S.E. trade-wind blows from a few degrees E. of Madagascar to the coast of Australia, between 10° and 28° S. lat. The trade-winds are only constant far from land, because the diminished atmospheric pressure from the heating effects of the sun on continents and islands combined with the rotation of the earth changes them into periodical monsoons, which are steady currents of air in the Arabian Gulf, the Indian Ocean, and the China Seas.

When the sun has crossed the equator, and his vertical rays fall on the extensive and arid plains of Asia, the great mass of superincumbent air, being highly rarefied, ascends, and winds from all neighbouring regions converge to this space by indraught. But since the calms of Cancer do not extend to the Indian Ocean, the S.E. trade-winds pass into the northern hemisphere; and as they also are drawn into the vortex over the land to maintain the equilibrium, they are deflected from their course, and, being at once acted upon by the indraught to the heated plains and the rotation of the earth, they become S.W., S., S.E., and E. monsoons at different points on the coast of Asia. But as soon as the sun passes into the southern hemisphere the Asiatic plains become cool, and the S.E.

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[1] Buchan's 'Handy Book of Meteorology.' 2nd Edition.

trade-winds resume their wonted course, and from October to April they become the S.E. monsoon, so that the S.E. trade-wind in the Indian Ocean is alternately a trade-wind and a monsoon.

The influence of these heated plains upon the winds is felt for a thousand miles and more at sea. Thus, though the desert of Gobi and the sun-burned plains of Asia are for the most part north of the latitude of 30°, their influence in producing monsoons is felt S. of the equator. In like manner the Central American monsoons of the Pacific are caused by the heated plains of Utah and Texas; those of the Mexican Gulf by the dry lands of New Mexico; and the monsoons in the Gulf of Guinea by the sandy deserts of Africa. Thus the monsoons are not occasioned by the sun's action on the sea, but by his action on the land; and it is to the N. of the N.E. trade-winds that most of these deserts lie.[1] Similarly also, the heated interior of Australia causes an indraught of air during the time that the sun is S. of the equator, and a N.W. monsoon caused by the reversal of the S.E. trades, brings rain to all the northern coast of that island-continent.

The Society and Sandwich Islands, that are far removed from any large extent of land, have a very singular but marked effect upon the wind. They interfere with the trades very often, and turn them back, for westerly and equatorial winds are common at both these groups, but they are local and of little extent.

The changes of the monsoons are accompanied by heavy rain and violent storms of thunder and lightning. The ascent of the warm air between the tropics occasions a depression of the barometer amounting to the tenth of an inch, which is a measure of the force producing the trade-winds.[2] In both hemispheres there is a regular variation in the mean height of the barometer within the zone in which these great aërial currents flow; it is higher at their polar limits, and decreases with extreme uniformity towards their equatorial boundaries, the difference in both hemispheres being 0·55 of an inch.

The unequal temperature of the land and sea causes sea-breezes which blow towards the land during the day, and land-breezes which blow seaward in the night: the former are by much the strongest, for the difference of the temperature of the air over the land and over the sea is greater during the day than in the night; they are not perceptible in the mornings and evenings, because the temperature of the land and water is then nearly the same. In the early morning the sea is calm and the wind at rest, but when the sun has warmed the land it rarefies the air above it, which ascends, and cool air from the ocean comes to supply its place. At first it appears far off as a fitful dark line upon the glassy sea; then it comes in a gentle ripple, which by degrees freshens into a brisk breeze, changing the molten surface into the deepest azure. At sunset the land begins to radiate its heat into space; by degrees the breeze dies away, till the air over the earth becomes cooler and heavier than that over the sea, and a land-wind rises which lasts till morning. It is impossible to describe how grateful these breezes are in a tropical country—drooping nature revives under their benign influence.

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[1] 'Physical Geography of the Sea.' (Maury.)

[2] Sir John Herschel has observed that, on account of the upper flow of heated air not being immediately compensated by polar currents, the barometer is two-tenths of an inch higher at the tropics than at the equator. Ermason, by careful observations in the Pacific and Atlantic oceans, makes this difference only 0·15 of an inch, which is that stated in the text.

The trade-winds and monsoons are permanent, depending on the motion of the sun; but it is evident from theory that there must be partial winds in all parts of the earth, occasioned by the local circumstances that affect the temperature of the air. Consequently the atmosphere is divided into districts, both over the sea and land, in which the winds have nearly the same vicissitudes from year to year. The regularity is greatest towards the tropics, where the causes of disturbance are fewer. In the higher latitudes it is more difficult to discover any regularity on account of the greater proportion of land, the difference in its radiating power, and the greater extremes of heat and cold; besides, on account of the form of the earth, the extratropical surface-winds come into areas vastly less than those they have left, consequently they are compressed or heaped up, which makes them more ready to come into conflict with those winds that may be raised by local causes. But even in these latitudes a degree of uniformity prevails in the succession of the winds; for example, in all places where N. and S. winds blow alternately, a vane veers through every point of the compass in the transition, and in some places the wind makes several of these gyrations in the course of the year.[1] The south-westerly winds so prevalent in the Atlantic Ocean between the 30th and 60th degrees of N. latitude are produced by the under-current going N. from the calm belt of Cancer, and, as it has a greater rotatory motion than the earth in these latitudes, it produces a south-westerly wind. On this account the average voyage from Liverpool to New York in a sailing-vessel is 40 days, while it is only 23 days from New York to Liverpool. For the same reason the average direction of the wind in England, France, Germany, Denmark, Sweden, and North America, is some point between S. and W. North-westerly winds prevail in the corresponding latitudes of the southern hemisphere from the same cause. In fact, whenever the air has a greater velocity of rotation than the surface of the earth, a wind more or less westerly is produced; and when it has less velocity of rotation than the earth, a wind having an easterly tendency results. Thus there is a perpetual change between the different masses of the atmosphere, the warm air tempering the cold of the higher latitudes, and the cold air mitigating the heat of the lower; it will be shown afterwards that the aërial currents are the bearers of elements on which the life of the animal and vegetable world depends.

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[1] In the northern hemisphere a north wind sets out with a less rotary motion than the places have at which it successively arrives, consequently it veers through all the points of the compass from N. to N.E. and E. If a south wind should now spring up, it would gradually veer from S. to S.W. and W., because its rotary velocity would be greater than that of the places it successively comes to. The combination of the two would cause a vane to veer from E. to S.E. and S.; but the rotation of the earth would now cause the south wind to veer round from S. to S.W. and W.; and should a north wind now rise, its combination with the west wind would bring the vane round from W. to N.W. and N. again. At the Greenwich Observatory the wind makes five gyrations in that direction in the course of a year. In Europe it is the contention of the N.E. and S.W. winds, which

A rapid fall in the barometer is an invariable sign of an approaching gale; so certain, that no ship, much less a coasting-vessel on our dangerous coasts, ought to be without one, either to give warning not to sail, or to seek immediate shelter if at sea. This simple and cheap instrument might have saved hundreds who have annually perished in the British seas. A sudden and great fall in the mercury is also a fearful presage of a revolving tempest or hurricane.

§ 5. Hurricanes are those storms of wind in which the portion of the atmosphere that forms them revolves in a horizontal circuit round a vertical or somewhat inclined axis of rotation, while the axis itself, and consequently the whole storm, is carried forwards along the surface of the globe, so that the direction in which the storm is advancing is quite different from the direction in which the rotatory current may be blowing at any point; the progressive motion may continue for days, while the wind accomplishes many gyrations through all the points of the compass in the same time. In the Atlantic the principal region of hurricanes is to the E. of the West India islands, and in the Indian Ocean to the E. of the island of Madagascar: consequently the former is in the northern hemisphere, the latter in the southern; but in most cases the storm moves in an elliptical or parabolic curve. The West Indian hurri-

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causes the rotation of the wind and the principal changes of weather, the S.W. being warm and moist, the N.E. cold and dry, except where it comes over the North Sea.

canes generally have their origin eastward of the Lesser Antilles or Caribbean islands, and the western vortex of their path near the tropic of Cancer, or about the exterior limit of the N.E. trade-wind. The motion of the storm, before it reaches the tropic, is nearly in a straight line from S.E. to N.W., and after it has passed the tropic from S.W. to N.E., the convexity of the curve is turned towards Florida and the Carolinas. In the South Pacific Ocean the body of the storm moves in an exactly opposite direction. The hurricanes which originate S. of the equator, and whose initial path is from N.E. to S.W., turn near the tropic of Capricorn, and then trend from N.W. to S.E., so that the convexity of the curve is turned towards Madagascar.

The West Indian hurricanes occur most frequently from July to October. Typhoons on the coasts of Hindostan happen from May to October, most often in July, August, and September. In the South Indian Ocean they fall between November and May during the N.W. monsoon in the Indian Archipelago.

In the Atlantic these dreadful storms are caused by the irregularity in the temperature of the Gulf-stream and of the neighbouring regions, both of air and water. A difference of 48° Fahr. has been observed between the temperature of that stream and the air on each side of it, whence Captain Maury concludes that "the excess of heat daily brought into such a region by the waters of the Gulf-stream would, if suddenly stricken from them, be sufficient to make the column of the superincumbent atmosphere hotter than melted iron. With such an element of atmospherical disturbance in its bosom, we might expect storms of the most violent kind to accompany it in its course. Accordingly, the most terrific that rage in the ocean have been known to spend their fury within or near its borders."

The extent and velocity of the Atlantic hurricanes are very great; the most rapid move at the rate of 45 miles an hour. The hurricane which took place on the 12th of August, 1830, was traced from the eastward of the Caribbean islands to the banks of Newfoundland, a distance of more than 3000 miles, which it passed over in six days. Although that of the 1st of September, 1821, was not so extensive, its velocity was greater, as it moved at the rate of 30 miles an hour. The Bahama hurricane of October, 1866, moved at the speed of 30 miles an hour, when it was nearing Bermuda; but the violence and destructiveness of the hurricane depend not on the velocity with which the whole storm moves, but on the speed with which the winds whirl round and in upon the centre. In the Bahama hurricane this was at the rate of 80 to 100 miles an hour, and for short intervals even 120 to 130 miles an hour, a velocity like that which was registered during the Guadaloupe hurricane of September, 1865. Small storms are generally more rapid than those of great magnitude.

Sometimes they appear to be stationary, sometimes they stop and again proceed on their course, like water-spouts. Hurricanes are often contemporaneous, and occur near to one another. This happened in the China Seas in October, 1840, when the two storms met at an angle of 47°, and it was supposed that the ship 'Golconda' foundered in that spot with 300 people on board. A hurricane has been split or divided by a mountain into two separate storms, each of which continued its new course, and the gyrations were made with increased violence. This occurred in the gale of the 25th of December, 1821, in the Mediterranean, when the Spanish mountains and the maritime Alps became new centres of motion.

The whirling motion of these fearful storms begins in the higher regions of the atmosphere before it is felt on the earth. During their course there is a continual intermixture of the lower and warmer strata of air with those that are higher and colder, producing torrents of rain, and sometimes violent electric explosions.

The rotation as well as the course of the storm is in a different direction in the two hemispheres, though always alike in the same. In the northern the gyratory movement of the wind is from E., through the N., to W., S., and E. again; while in the southern hemisphere the rotation about the axis of the storm is in the contrary direction. Hurricanes happen S. of the equator between December and April; in the West Indies between June and October. Rotatory storms frequently occur in the Indian Ocean, and the typhoons of the China Seas are real hurricanes of great violence. Both conform to the laws of such winds in the northern hemisphere. The Atlantic storms occasionally reach Spain, Portugal, and the coast of Ireland. Tremendous storms often pass over Great Britain, and lesser ones often occur between the Chops of the Channel and Madeira. A great hurricane passed over Ireland and the west coast of England in January, 1839. A strong gale had blown from S.S.E. on the 6th, when about 10 in the evening the air became calm and warm, which was evidently during the passage of the axis of the storm, for soon after the gale was renewed with the utmost violence, but now it was from the S.W. and W.S.W., and on the evening of the 7th was accompanied by snow, thunder, lightning, and intense cold. At Leeds, 70 miles distant from the Irish Sea, and separated from it by a ridge of hills, there was everywhere a saline deposit.

Recent investigations have shown that the storms of Europe and North America move from W. to E., or from S.W. to N.E., and that the winds circle round the area of least pressure, with a constant tendency to turn inwards towards that area.

The temperature of winds depends upon the nature of the surface over which they blow. In Europe the coldest and driest wind is from the N. and N.N.E.; in America it is from the N. and N.N.W., because both come from the polar ice, and sweep over extensive tracts of land. The warm and moist winds in Europe are from the S.W., because they blow over a great extent of ocean, especially on the western side of the continent. The Puna winds which blow on the barren table-land of Puna to the E. of Arequipa, in Peru, are cold, dry winds, which, having crossed the Cordilleras, have become parched to an extent which has no equal anywhere in the world. When a mule dies in crossing these plains it is dried to a mummy in a few days. In this district the ancient inhabitants of Peru preserved their dead; and travellers have to protect their faces from the glare and heat of the day, and the intense cold of the night.

The revolving motion accounts for the sudden and violent changes observed during hurricanes. In consequence of the rotation of the air, the wind blows in opposite directions on each side of the axis of the storm; and the violence of the blast increases from the circumference towards the centre of gyration, but in the centre itself the air is in repose: hence, when the body of the storm passes over a place, the wind begins to blow moderately, and increases to a hurricane as the centre of the whirlwind approaches; then in a moment a dead and awful calm succeeds, suddenly followed by a renewal of the storm in all its violence, but now blowing in a direction diametrically opposite to what it had before. This happened in the island of St. Thomas on the 2nd of August, 1837, where the hurricane increased in violence till half-past seven in the morning, when perfect stillness took place for 40 minutes, after which the storm recommenced in a contrary direction. The breadth of a hurricane is greatly augmented when its path changes its direction in crossing the tropic. In the Atlantic the vortex of one of these tempests has covered an area from 600 to 1000 miles in diameter. The diameter of the storm in the Southern Indian Ocean is generally from 1000 to 1500 miles; and the general rate of motion is from four to seven miles an hour. The breadth of the lull in the centre varies from five to 30 miles; the height is from one to five miles at most: so that a person might see the strife of the elements from the top of a mountain such as Teneriffe or Mauna Roa, in a perfect calm, for the upper clouds are frequently seen to be at rest during the hideous turmoil in the lower regions. When the centre of the Bahama hurricane of 1866 passed over Nassau, the calm lasted an hour and a half, from 7·20 to 8·50 P.M. At 7·30 the clouds in the zenith, which before had appeared to be revolving rapidly, rose, and the stars appeared, while banks of cloud remained all round the horizon in heavy dense masses. The calm covered an area of 23 miles across.

The sudden fall of the mercury in the barometer in latitudes habitually visited by hurricanes is a certain indication of a coming tempest. The air becomes rarefied; and as the atmosphere is disturbed to some distance beyond the actual circle of gyration, or the limits of the storm, the barometer often sinks some hours before its arrival: it continues sinking the first half of the hurricane, and again rises during the passage of the latter half, though it does not attain its greatest height till the storm is over. During the West Indian hurricane of October 1st, 1866, while the storm was passing, the barometer fell 0·7 inch in an hour; and during the hurricane which devastated Guadaloupe, September 6th, 1866, at Marie Galante, the barometer is said to have fallen 1·693 inch in an hour. The diminution of atmospheric pressure extends over a wider area in the temperate zones than in the torrid.

As the fall of the barometer gives warning of the approach of a hurricane, so the laws of a storm's motion afford to the seaman knowledge to avoid it. In the northern temperate zone, if the gale begins from the S.E. and veers by S. to W., the ship should steer to the S.E.; but if the gale begins from the N.E., and changes through N. to N.W., the vessel ought to go to the N.W. In the northern part of the torrid zone, if the storm begin from the N.E. and veer through E. to S.E., the ship should steer to the N.E.; but if it begin from the N.W. and veer by W. to S.W., the ship should steer to the S.W., because she is on the south-western side of the storm. Since the laws of storms are reversed in the southern hemisphere, the rules for steering vessels are necessarily reversed also.[1]

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[1] In all hurricanes hitherto observed, the sinking of the mercury, and the increase of the wind, have been more or less regularly progressive till within three or four hours' sail of the centre of the storm; and in one class they have continued so even to the centre; while in another class, and by far the most terrible, the depression of the mercury has been sudden and excessive when within that distance of the centre, and the violence of the tempest far beyond the average. When a ship is within 50 or 60 miles of the centre, the storm has the mastery, and seamanship is of little avail. Rules for avoiding this calamity, and for managing a ship when involved in a hurricane, are fully explained in the 'Hurricane Guide' by William Radcliff Birt, published under the sanction of the Admiralty, in 12mo., London, 1850; a little book in which the navigator will find information conveyed in a very intelligible manner on the subject; and in the new edition, 1851, of the 'Sailor's Horn-Book for the Laws of Storms,' by H. Piddington, Esq., President of the Marine Courts of Inquiry at Calcutta. The following approximate table is given by the latter author to serve as a guide till better data should be obtained:—

Average fall of the barometer per hour.	Distance of a ship from the centre of the storm, in miles.
From 0·020 to 0·060	From 250 to 150
„ 0·060 „ 0·080	„ 150 „ 100
„ 0·080 „ 0·120	„ 100 „ 80
„ 0·120 „ 0·150	„ 80 „ 50

A heavy swell or storm-wave is peculiarly characteristic of these tempests. In the centre of the hurricane the pressure of the atmosphere is so much diminished by rotation, that the mercury in the barometer falls from one to two, and even two and a half inches. On that account the pressure of the ocean beyond the range of the wind raises the water in the centre of the vortex about two feet above its usual level, and proportionally to the degree of diminished pressure over the whole area of the storm. This mass of water, or storm-wave, is driven bodily along with or before the tempest, and rolls in upon the land like a huge wall of water. It is similar to the earthquake-wave, and is by no means the heaping up of the water after a long gale. Ships have been swept by it out of docks and rivers, and it has sometimes carried vessels over reefs and banks so as to land them high and dry: this happened to two ships on the coast of the Eastern Andaman islands in 1844. Coringa, on the Coromandel coast, is particularly subject to inundations from that cause. In 1789 the town and 20,000 inhabitants were destroyed by a succession of these great waves during a hurricane, and as many perished there in 1839. On October 5th, 1864, a great storm passed over Calcutta, and the storm-wave which accompanied it, rising 10 feet above the highest spring-tides, laid the level country at the mouth of the Ganges under water, and caused the destruction of 45,000 persons.

Besides storm-waves, storm-currents are raised, which revolve with the rotation of the wind, and are of the greatest force near the centre of the vortex.

The rise of the sea, by the pressure of the surrounding ocean and the irresistible fury of the wind, makes a tremendous commotion in the centre of the storm, where the sea rises, not in waves, but in pyramidal masses. The noise during its passage resembles the deafening roar of the most tremendous thunder; and in the typhoons

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The rate of fall per hour doubles after the storm has lasted six hours, and within three hours of the centre of the hurricane the mercury will fall four times as fast, if it be of the violent class.

Colonel James Capper was amongst the first to point out the rotatory motions of storms, as Mr. W. C. Redfield, of New York, was to determine their laws. General Reid, Governor of Malta, and Mr. Piddington, of Calcutta, have also written ably, and added greatly to our knowledge, on the subject. Professor Dove, the great meteorologist of Berlin, has proposed a very ingenious explanation of the origin of rotatory storms by lateral currents in the upper atmosphere, produced by the overflow occasioned by ascending currents over highly heated districts (See Report of R. S. to Gov. on Meterological Observations); whilst Mr. Birt has united in a very abridged and useful form the practical information collected by the authors who preceded his little essay on Hurricanes. Of late years this subject has occupied much attention in India and the United States as well as in European countries.

in the China seas it is like numberless voices raised to the utmost pitch of screaming. In general there is very little thunder and lightning; sometimes a vivid flash occurs during the passage of the centre, or at the beginning of the storm; yet in Barbadoes the whole atmosphere has been enveloped in an electric cloud.

A thick lurid appearance, with dense masses of cloud in the horizon, ominous and terrible, are the harbingers of the coming tempest. The sun and clouds frequently assume a fiery redness, the whole sky takes a wild and threatening aspect, and the wind rises and falls with a moaning sound, like that heard in old houses on a winter's night. It is akin to the "calling of the sea," a melancholy noise which, in a dead calm, presages a storm on some parts of the English coast.

Those intensely violent gales, of short duration, called *arched squalls*, because they rise from an arch of clouds on the horizon, are not rotatory: they occur in the Strait of Malacca, attended by fierce thunder and lightning and a lurid phosphorescent gleam. The north-western gales in the Bay of Bengal, the tornadoes on the African coast and the pamperos of the Rio de la Plata, are of the same nature. The pampero blows in summer from the Andes across the pampas of Buenos Ayres to the sea-coast. It is a dry wind, bringing clouds of dust and drying up the vegetation of the pampas. On an average a strong gale moves at the rate of 40 miles an hour,[1] a storm at about 59, and hurricanes at 90.[2] Deserts, especially those of Africa and Asia, are subject to intensely hot winds of short duration, frequently fatal to exhausted travellers: of these the simoom and sand-wind are the most formidable. A red lurid appearance in the atmosphere, caused by the quantity of burning sand raised by the wind, gives warning of their approach; everything is scorched in their passage, and breathing becomes painful. It is probably owing to the sand wafted by them, and to their parching dryness, that these winds are so deleterious, and not only to their temperature, since air heated to a much higher degree may be breathed with impunity, as has been proved by Sir Joseph Banks and by Sir Francis Chantrey, in an atmosphere raised to more than 300°. The simoom generally blows from six to twenty-four hours, but sometimes it continues for two or three days, when it comes in gusts driving clouds of sand; nothing can withstand it. There can be no doubt that sudden changes of temperature occasion these formidable winds.

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[1] The average rate of motion of European storms is about 18 miles an hour; sometimes the rate is only 15 miles an hour, whilst on rare occasions it is as great as 45 miles an hour.—*Buchan's* 'Meteorology.'

[2] A plan of conveying warnings of approaching storms was invented by the late Admiral Fitzroy, and was in operation for some time. In the two years ending March 1865, the warnings of the first year were right in 50 per cent., and in the second year in 73 per cent. of the cases. The warnings were suspended for a short period, but were renewed in May, 1867. Notice is now sent of the actual existence of a storm, and the places to which the telegrams go, may, if they choose, benefit by the warning.

Hot winds from Africa blow in all the neighbouring countries; but receive important modifications from the nature of the country over which they pass. The hot moist Sirocco blows in Sicily, South Italy, Turkey (where it is called the Samiel, on account of its reputed poisonous nature), and even to the shores of the Black and Caspian Seas and the Steppes beyond the Volga. The Spanish Solano is hot and loaded with fine dust, and the Harmattan of Guinea and Senegambia, under whose influence no dew falls, withers up vegetation between December and February. The low atmospheric pressure to the S. and the high pressure in the interior of North America during winter combine to cause the dry, cold and violent winds called "Northers" which prevail from September to March in the Gulf of Mexico. The violence of the winds in the S. of Europe—the result of the differences in temperature of the Alps, the Mediterranean and Africa—is notorious. The cold, tempestuous Bora, which sweeps from the Julian Alps over the Adriatic, and the violent Mistral, which blows from France down on the Gulf of Lyons, are two of these winds.

Whirlwinds are frequent in tropical countries, especially in deserts; sometimes several are seen at one time in the Arabian deserts, of all sizes, from a few feet to some hundred yards in diameter. They occur in all kinds of weather, by night as well as by day, and come without the smallest notice, rooting up trees, overwhelming caravans, and throwing down houses; and as they produce water-spouts when they reach the sea, they dismantle and even sink ships. Pillars of sand are often raised by them on the African deserts two or three hundred feet high. In Nubia Bruce saw eleven advancing towards him with considerable swiftness. It was vain to think of flying where the speed of the swiftest horse could have been of no avail, and that conviction riveted him to the spot. They retreated, leaving him in a state of mind between fear and astonishment, to which he could give no name. Whirlwinds advance with a loud rushing noise, and are frequently attended by electrical explosions. At the close of the storm a fall of rain generally takes place. Dust whirlwinds prevail in India and Nubia. Sir S. W. Baker describes those of Nubia in April, May, and June:—"I have frequently seen many such columns at the same time in the boundless desert, all travelling or waltzing in various directions, at the fitful choice of each whirlwind: this vagrancy of character is an undoubted proof to the Arab mind of their independent and diabolical nature." The water-spouts so frequently seen on the ocean originate in adjacent strata of air of different temperatures, running in opposite directions in the upper regions of the atmosphere. They condense the vapour, and give it a whirling motion, so that it descends tapering to the sea below, and causes the spray of the agitated water to ascend in a pointed spiral till it joins that from above, and then it looks like two inverted cones, being thinner in the middle than either above or below. When fully formed they appear as tall pillars stretching from the sea upwards to the clouds, and exhibiting the same whirling round their axis, and the same progressive movement of the mass as in dust-whirlwinds. When a water-spout has a progressive motion, the upper and under part must move in the same direction, and with equal velocity, otherwise it breaks, which frequently happens.

CHAPTER XXIV.

ATMOSPHERIC PHENOMENA—*continued.*

§ 1. Evaporation; distribution of vapour; dew; hoar-frost; fog. § 2. Region of clouds; forms of clouds. § 3. Rain; distribution of rain; quantity; number of rainy days in different latitudes; rainless districts. § 4. Snow; various forms of its crystallization; line of perpetual snow; limit of winter snow on the plains; sleet; hail. § 5. Light; minuteness of the ultimate particles of matter; their densities and forms; their action on light; colour of bodies; colour of the atmosphere; its absorption and reflection of light. § 6. Mirage; fog images; coronæ and halos; the rainbow; iris in dewdrops. § 7. Polarization of the atmosphere. § 8. Atmospheric electricity; its variations; electricity of fogs and rain; inductive action of the earth; lightning; thunder; distribution of thunder-storms; back stroke; St. Elmo's fire; phosphorescence. § 9. Magnetism; terrestrial magnetism; the dip; magnetic poles and equator; magnetic intensity; dynamic equator; declination; magnetic meridian; lines of equal variation; horary variations; line of alternate horary phenomena; magnetic storms; coincidence of the lines of equal magnetic intensity with mountain-chains; diamagnetism; aurora.

§ 1. MOISTURE is evaporated in an invisible form from every part of the land and water, and at all temperatures, even from snow. Mr. Darwin mentions that the snow once entirely disappeared from the Nevado of Aconcagua, in Chile, which is 23,910 feet high, from evaporation under a cloudless sky and an excessively dry air. The vapour rises and mixes with the atmosphere; and as its pressure and density diminish with the height above the surface of the earth, in consequence of gravitation, there is absolutely less moisture in the higher than in the lower regions of the air.[1]

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[1] The humidity of the air is measured by the Hygrometer, an instrument which shows the rapidity of evaporation at all temperatures; for the rate of evaporation is in proportion to the dryness of the atmosphere, and is nearly in the inverse ratio of the density. When the evaporation is below 30° on the scale of the hygrometer the air is very dry, when above 80° it is intensely damp. The most accurate mode of determining the quantity of moisture in the air is by the wet-bulb thermometer, which shows the temperature of evaporation; hence the temperature at which the atmosphere is saturated with humidity is easily found in the tables. Daniels' Hygrometer and August's Psychrometer are to a certain degree founded on this principle.

The trade-winds promote evaporation, for as soon as the vapour is formed they carry it off, otherwise the atmosphere would become saturated, and no more would rise. From the surface of the whole globe it has been computed that 186,240 cubic miles of water is annually raised in the form of vapour, and annually descends in rain, hail, and snow. The air is the storehouse, the winds the swift messengers who carry it to water the land and feed the rivers. The power of the sun and air to raise and carry this immense mass must be enormous. It is on the same stupendous scale in which all the mighty operations of nature are conducted.

There are about 25 millions of square miles of sea in the northern hemisphere, and nearly 75 in the southern; besides, the zone of the S.E. trade-winds is much greater than the northern, and covers three times as much water: yet the mean annual amount of rain in the northern hemisphere is probably about 37 inches, and 26 in the southern; for the vapour from the great reservoirs at the equator and the southern hemisphere is wafted by the S.E. trade-wind in the upper regions of the atmosphere till it comes to the calms of Cancer, where it sinks down and becomes a S. and S.W. surface-wind, and then the condensation begins that feeds all the greatest rivers in the world. The atmosphere is much more unstable in the northern hemisphere with its excess of land, than in the southern with its excess of water. Rains, fogs, thunder, calms, and storms, all occur much more frequently, and are much more irregular also as to time and place, on this side than they are on the other side of the equator. The evaporation is greatest between the tropics, from the excess of heat and the preponderance of the ocean, and its average quantity decreases from thence to the poles. Over the open sea, in all latitudes, the air contains a larger proportion of moisture than in the interior of the continents; the evaporation diminishing from the coasts to the interior of the latter: so that in the interior of the United States of North America, in the deserts of Asia, and in the interior of Australia, the aqueous vapour contained in the air is very small. There is scarcely any evaporation in the deserts of Africa, and the extreme heat, increased by the highly heated sand, opposes aqueous precipitations; and as the winds which blow over it increase in temperature and so become drier, this land is doomed to perpetual sterility. The air over the steppes of Siberia is likewise nearly devoid of moisture. A very great degree of dryness was observed by M. Ermann between the valleys of the Irtish and Oby, after a continued S.W. wind with a temperature of 74°·7 of Fahrenheit.

Throughout all the countries in the northern hemisphere where observations have been made on the variations of atmospheric moisture, it appears that the air contains absolutely less vapour in January than in any other month of the year, yet at that time there is the greatest dampness to our sensations; while in July the air feels driest, although, on account of the heat, evaporation is the greatest. In summer the dew point is much further below the temperature of the air than in winter, hence the air is drier. If the temperature of air containing a certain amount of vapour is raised, its relative humidity becomes less, and to the sensation it is drier. The proportion of vapour in the air varies generally with the direction of the wind: in Europe it is greatest in a S.W. wind, and least in a N.E. and N.W.; the former, being part of the equatorial current drawn down to the surface of the globe, comes warm and moist over the Atlantic, while the northern wind blows dry and cold from the pole. The moisture in the atmosphere obstructs the free passage of the heat resulting both from solar and from terrestrial radiation. This is one of the most important of the purposes served by the moisture in the atmosphere. If the air contained no moisture, the radiation from the earth's surface during the night would be so rapid and excessive that all living things would be destroyed. Mountainous countries, where, owing to the elevation, there is a comparatively small amount of aqueous vapour in the atmosphere, feel the effects of comparatively unobstructed radiation. The traveller over snow-fields is scorched by the blaze of the sun. In polar regions, also, the intense heat of the sun's rays is the result of the want of vapour in the atmosphere. When the moisture is abundant and the tension great, which is often the case before rain, the air is very transparent, and distant objects appear nearer, and all their details are more distinctly seen: from this circumstance the clearer view of distant mountains and headlands indicates wet weather. Very dry air is also exceedingly transparent, as on the tops of very lofty mountains, and in sandy deserts, where the stars are seen to shine with uncommon lustre, and the brighter planets are visible in the daytime. On account of the heat, the air between the tropics contains more moisture than elsewhere; and were it not for the amount of evaporation, the warmth there would be greater than it is, for a depression of temperature takes place during evaporation by the absorption of the heat, which thus becomes insensible to the feelings and to the thermometer. The evaporation and consequent absorption of heat may be so rapid as to produce intense cold; upon this principle the speedy evaporation of ether or chloroform by means of a current of air will freeze water upon the outside of the vessel in which either of these volatile liquids is contained.

The quantity of atmospheric moisture varies also with the hours of the day and night. In early morning the evaporation accumulates near the surface of the ground from the resistance of the air above it to its free diffusion, but, as the sun rises above the horizon and warms the earth, the air becomes rarefied and ascends, carrying the vapour with it; so that the quantity near the ground is diminished till evening, when, on account of the lowness of the temperature, the ascending currents cease, and the air becomes loaded with vapour and deposits its excess in the shape of dew or hoar-frost. For in the night the earth radiates part of the heat it received during the day through the atmosphere into space, and the temperature of the bodies on its surface sinks below that of the air; and by abstracting part of the heat which holds the humidity of the air in solution a deposition takes place. The dew-point is the temperature at which vapour is deposited on bodies colder than itself, but before any deposition takes place the air must be saturated with moisture at the temperature of the body upon which the dew is deposited. It is very abundant on the shores of continents, but it is not deposited on small islands in the midst of large seas, because on them the difference between the temperature of the day and the night is not sufficiently great. Dalton estimated that the quantity of dew that falls in England annually would form a bed of water uniformly spread over the whole kingdom of five inches in depth. If the temperature fall to or below 32°, the dew is frozen and becomes hoar-frost, which is the ice of dew. Cloudy weather and windy weather are unfavourable for the formation of dew; the former by preventing the free radiation of heat into space, and the latter by constantly renewing the air in contact with the ground, and thus preventing the temperature from falling sufficiently low. Actual contact is necessary for its formation, as it is never suspended in the air like fog. Dew falls in calm serene nights, but not on all substances indifferently; it wets them in proportion to their powers of radiation, leaving those dry that radiate feebly or not at all. Dew is most abundant on coasts; in the interior of continents there is very little, except near lakes or rivers. When dew is congealed into hoar-frost it forms beautiful crystals, and the cold which produces it is very hurtful to vegetation, but the slightest covering preserves plants from its effects.

When the atmosphere is so saturated with the vapour of water that it is precipitated in the air itself, a fog is the result, which is supposed to consist of small globular particles of water. When dew is formed, the earth is colder than the air in contact with it; but the case is exactly the contrary when fogs take place, the moist soil being warmer than the air. In countries where the soil is moist and warm, and the air damp and cold, thick and frequent fogs arise, as in England, where the coasts are washed by a sea of elevated temperature from the Gulf-stream, and the excess of the heat of the Gulf-stream above the cold moist air is the cause of the perpetual fogs in Newfoundland, and on the approach of winter those dense fogs known to seamen as frost-smoke, steam from the Polar Ocean till it is frozen over. Fogs rarely occur at sea between the parallels of 30° N. and S. latitude, that is over half the globe. For one fog within these limits in the Atlantic, no less than 83 take place on the polar side; and although these fogless regions are occasionally subject to hurricanes, a gale of wind is very rare.[1]

§ 2. Superior to all these phenomena, and at a considerable height above the earth, the air is very dry, because under ordinary circumstances the vapour ascends in a highly elastic and invisible state till it reaches a stratum of air of lower temperature, and then it is condensed into clouds. The region of clouds is a zone at a height varying from 1300 to 21,320 feet (according to Kämtz's measurements) above the surface of the earth. Balloon ascents, have, however, found that this height is much too small. Gay Lussac, when at a height of 23,000 feet, saw clouds floating apparently at a great height above him, and Mr. Glaisher has made the same observation. It is probable that the cirrus clouds are often ten miles above the earth. From friction and other causes the currents of air in the lower parts of that zone run horizontally on each other, often in different and frequently in opposite directions; and as they generally differ in moisture, temperature, and velocity, the colder condense the invisible vapour in the warmer, and make it apparent in the form of a cloud, which differs in no respect from a fog, except that one floats high in the air, while the other rests on the ground. When a heavy and dry wind begins to set in or take the place of a moist and light wind, it generally does so by edging itself beneath the moist wind and forcing it wedgeways into the upper regions of the atmosphere, where condensation rapidly follows, and dense black clouds, often heavily charged with rain, are formed. In Britain the heavy E. or polar current, thrusts high up into the air the rain-bringing S.W. wind, causing it to darken the sky and pour down torrents of rain.[2]

In the balloon ascents at Kew it was observed that the cloud region there, is from 2000 to 6500 feet above the surface of the earth, that its thickness varies from 2000 to 3000 feet, and that the temperature at the top is the same with that at the bottom of the stratum. The cloud region of the trade-winds is from 3000 to 5000 feet high, and it is generally higher over the sea than over the land for the same amount of vapour in the wind. In the North temperate zone the cloud region is high over the land and low over the water; and, as a rule, the farther inland the drier the air and the higher the cloud region.

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[1] In the North Atlantic the foggy and stormy latitudes are between 45° and 60° N., and in the South Atlantic the most foggy region is between 50° and 60° S. lat., the most stormy between 50° and 55°.—*Captain Maury.*

[2] Buchan's 'Meteorology.'

At moderate heights clouds consist of vapour, but at great elevations where the cold is severe they are an assemblage of minute crystals of ice. The particles of which clouds are composed undergo constant renewal or change. As Espy has said, every cloud is either a forming or a dissolving cloud. When it is connected with an ascending current, it increases in size, is dense at the top, and well-defined in its outlines; but when the ascending current ceases, and the particles begin to fall through the air by their weight, the cloud diminishes in size and density. Clouds near the earth take the contour of the land over which they are formed. Above the lower stratum of clouds there is frequently a clear space of air, above which are more clouds, then another clear space, and so on in succession. The appearance of the clouds, as seen in balloon ascents, is often very gorgeous.

Clouds assume three primary characters, from whence four subordinate forms are derived. The cirrus, or cat's-tail of sailors, is the highest; it sometimes resembles a white brush, at other times it consists of horizontal bands of slender silvery filaments. It is probable that they consist of minute spicules of ice or flakes of snow. The cirri for the most part arrange themselves in parallel bands which, by the effects of perspective, converge to opposite points in the horizon, and as they travel in their longitudinal direction they appear to be stationary. In the middle and higher latitudes of the northern hemisphere they often trend from S.W. to N.E. In Scotland they have been observed to advance from S.W. to N.W. towards N.E. to S.E. It is supposed that their parallel form arises from their being conductors between two foci of electricity, but, whatever the cause of this arrangement may be, it is very general; they are supposed by Humboldt and Arago to be connected with the phenomena of the aurora. Among these clouds, which occasionally appear like fleecy cotton or wool, halos and parhelia are formed, which often precede a change of weather announcing rain in summer, in winter frost and snow.

Cumuli or summer-clouds are rounded forms, resembling mountains covered with snow. They are formed by ascending currents of warm air which rise from the heated ground, and they are the clouds of day. They are of dense structure, are formed in the lower regions of the atmosphere, and are carried along in the current next the earth; sometimes they rise and cover the whole sky, and in the evening they frequently become more numerous and of deeper tint, passing into denser forms which presage storm or rain.

The stratus is the third of the primary characters of clouds: it is a horizontal band, which forms at sunset and vanishes at sunrise; it is, therefore, the cloud of night, it includes all the mists which are found in the evenings in valleys and over low-lying grounds, and is the lowest of all the clouds. The subordinate varieties of clouds are combinations of these three principal classes.[1] The winds, the great agents in all atmospheric changes, carry the vapour to a distance, where it is often condensed on the tops of the mountains into clouds which seem to be stationary, but in reality they are only maintained by a constant condensation of fresh vapour, which is carried off, as soon as formed, by the wind, and becomes invisible on entering warmer air.

The rate at which clouds move is greater than is commonly supposed, exceeding considerably that of the wind at the surface of the earth. In May, 1867, when the rate of the wind was about 42 miles an hour, clouds were observed, near Edinburgh, which though moving with apparent slowness, were really travelling at the rate of 72 miles an hour; and, at another part of the same day, when the force of the wind was greater, the clouds moved at the rate of 109 miles an hour.

§ 3. If when two masses of air of different temperatures meet and mix together, the temperature falls below the point of saturation, the particles coalesce and form drops of water, which fall in the shape of rain by their gravitation. And when two strata of different temperature moving rapidly in contrary directions come into contact, a heavy fall of rain takes place; and as the quantity of aqueous vapour is most abundant in tropical regions, the drops are larger and the rain heavier there than elsewhere.[2]

The fall of rain, especially in low latitudes, depends upon the zone of trade-winds and calms. In the region of the trade-winds the sky is either mottled or serene, and the weather steady and delightful. These winds are the collectors and carriers of the vapour which the sunbeam raises from the ocean. But electricity also arises with the vapour, because it always accompanies evaporation provided the water be not pure; and as the sea-water contains many ingredients, a very great quantity is generated, rises with the vapour in the intertropical regions, and is poured with it into the belts of calms, in the higher regions of which there is a constant condensation from the crossing of winds of different temperatures, and tremendous thunder-storms are almost of daily occurrence, accompanied by torrents of rain. The equatorial belt of calms lies mostly N. of the equator in the Atlantic: in it these winds meet, and being highly elastic they ascend, till by the cold of the atmosphere they are condensed into the Cloud-ring, a stratum of clouds which surrounds the earth and overhangs the belt of calms, but leaves the sky clear on each side. New vapour is continually rising to the under surface of this cloud-ring, is condensed, and falls in constant rains: these rains fall during the day; and morning and evening are free from storms.

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[1] The four subordinate forms of clouds are the cirro-stratus, composed of little bands of filaments, more compact than the cirrus, forming horizontal strata, which seem to be numerous thin clouds when in the zenith, and at the horizon a long narrow band. The cumulo-stratus consists of the summer-cloud, like snowy mountains heaped on one another, which at sunrise have a black or bluish tint at the horizon, and pass into the nimbus, or rain-cloud, which has a uniform grey tint, fringed at the edges, —it often becomes a thunder-cloud; and the fourth is the cirro-cumulus, a combination of filaments and heaped-up cumuli or summer-clouds.

[2] Local circumstances have great influence, especially in the vicinity of mountains: probably the greatest average annual quantity on record is 302 inches, which falls on the western Ghauts, in 18° N. lat. At Guadaloupe it is 286 inches. In England the average annual quantity is 32 inches; nearly half that quantity fell in the first six weeks of 1848, which is more than had occurred for 33 years, and probably within a century.—Greenwich Meteor. Register.

In the belt of calms the air, being greatly heated by the vertical rays of the sun, ascends, drawing with it the whole mass of vapour the trade-winds have brought with them, and which has been greatly added to by the rapid evaporation from the belt of calms; this vapour is condensed as it rises to the line of junction of the lower and upper trades. The discharge is in some cases so copious that fresh water has been collected from the surface of the sea. The regularity of the daily rains in the belt of calms is only fully seen in the Pacific Ocean (Buchan's 'Meteorology.')

It has been mentioned that the whole zone of trade-winds and calms follow the sun in declination. Thus the equatorial belt of calms with its cloud-ring moves annually in the Atlantic from the 5th parallel of S. latitude to the 12th of N., and back again. In countries situate between the 5th and 10th parallels of S. and N. latitude, there are two rainy seasons, and two dry: one, which lasts between three and four months, occurs when the sun passes the zenith in his way to the nearest tropic, and the other at his return; but in the latter, which is not longer than six weeks or two months, the rains are less violent. With regard to the tropical belts of calms and rains, when the sun is N. of the equator rains prevail in the calms of Cancer, and when he is S. of that line under the calms of Capricorn: hence in all the latitudes over which these range, one period of the year is extremely wet and the other extremely dry; the change takes place at the equinoxes. At sea, within the limits of the trade-winds themselves, it seldom rains.

Although the quantity of water which falls between the tropics in a month is greater than that of a whole year in Europe, yet the number of rainy days increases with the latitude, so that there are fewest where the quantity of rain is the greatest. Neither does it fall continually during the rainy season between the tropics, for the sky is generally clear at sunrise, it becomes cloudy about 10 in the morning, at noon the rain begins to fall, and, after pouring for four or five hours, the clouds vanish at sunset, and not a drop falls during the night, so that a day of uninterrupted rain is very rare.[1]

Professor Secchi observes as a remarkable coincidence, that the period from noon to four or five o'clock should be exactly the time when clouds are formed at Rome, and which corresponds with the minimum of the diurnal range of the barometer at Rome and elsewhere over the globe.

The fall of rain depends much upon the direction of the land and mountains being parallel or perpendicular to the course of the prevailing winds. For instance, South and Central America run across the line of direction of the trade-winds and calms, which coming loaded with vapour pour down torrents of rain on the extensive eastern plains to feed the rich vegetation and supply the tributaries of the Orinoco and Amazon with water, so that when they reach the Cordilleras of the Andes they have just moisture enough left to whiten them with snow, and descend to the arid soils of Peru and New Mexico as dry and parching winds. The northern part of Chile is under the same influence during that season which is our winter; but when the sun goes N. with his attendant trade-winds and calms, Chile is left to the extratropical N.W. winds, which cooled by the temperature on the tops of its stupendous Andes deposit abundance of moisture.

In Chile and the south-western part of America winter is the rainy season; while on the eastern side of the Cordilleras, in the interior of the chain, the rains occur in summer. In Tierra del Fuego and the extreme point of the continent the two climatological provinces meet, periodical precipitation disappears, and it snows and rains throughout the year in torrents. At Cape Horn the quantity of rain which fell in 41 days measured nearly 154 inches. This excessive fall occurs along the whole western shores of Patagonia, from the strait of Magellan to Cape Tres Montes, a circumstance owing to the high and rugged coasts, and the prevailing extratropical N.W. winds that traverse the Pacific loaded with vapour.

The monsoon region furnishes another instance of the effect of mountain-chains upon the fall of rain. Throughout the whole of that region it is not the sun directly, but the winds, that regulate the periodical rains. That region extends from the eastern coasts of Africa and Madagascar across the Indian Ocean to the northern districts of Australia, and from the tropic of Capicorn to the face of the Himalaya, the interior of China, to Corea, and even round the N. of Siberia inclusive. In India and the Eastern Peninsula the western coasts are watered during the S.W. monsoon, which prevails from April to October; and the eastern coasts during the N.E. monsoon, which blows from October to April. For example, the S.W. wind condenses the vapour on the summit of the Ghauts, and violent rains fall daily on the coast of Malabar, while on the coast of Coromandel the sky is serene. Exactly the contrary takes place during the N.E. monsoon; it rains on the coast of Coromandel while there is fair weather on the Malabar coast, and the tableland of the Deccan partakes of both. In the southern hemisphere the rainy season corresponds with the N.W. monsoon, and the dry with the south-eastern.

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[1] At Demerara six inches have been known to fall in 12 hours. The quantity that falls in Italy is sometimes very great; at Rome half the yearly average quantity fell in 15 hours.

Since heat is the cause of evaporation, rain is very unequally distributed, and with it decreases from the equator to the poles. From the island of Haiti in the Antilles, to Uleàborg in Finland, the annual quantity of rain that falls decreases from 107 inches to 13. It is, however, more abundant in the New World than in the Old. The following rain-falls in the tropics are interesting:—Singapore, 97 inches; Canton, 78 inches; St. Benoit, Isle of Bourbon, 163 inches; Sierra Leone, 87 inches; St. Domingo, 107 inches; Bahamas, 52 inches; Vera Cruz, 183 inches; Doldrums of the Atlantic, 225 inches; Maranhao, 280 inches. The rainfalls of temperate regions vary—in the United States between 27 and 66 inches, and in Europe from 104 inches in the Alps to 15 inches in some parts of Sweden and Russia.

The greatest quantity of rain falls on the slopes of the mountains, on which prevailing winds first strike after having blown across the greatest extent of ocean. The more abrupt the elevation, and the shorter the distance between the mountains and the sea, the greater the amount of precipitation. For instance, on the western Ghauts the mean annual quantity is 302 inches. But the fall of rain at Khasyas, on the face of the Himalaya, is the greatest on record. Mr. Yule established the fact that in the month of August, 1841, there fell 264 inches of rain, or 22 feet, of which 12½ feet fell in the space of five consecutive days. This was confirmed by Drs. Hooker and Thomson, who measured 30 inches of rain in four hours, and above 500 inches in seven months. This terrific rainfall is attributed to the abruptness of the mountains which face the Bay of Bengal, and the intervening flat swamps 200 miles in breadth.

The extent of country on which rain seldom or never falls amounts to five millions and a half of square miles. The most extensive rainless desert stretches from Morocco eastward through North Africa, Arabia, Persia, and the desert province of Mekran in Beloochistan, occupying a space of 80 degrees of longitude and

17 of latitude. The Great Gobi on the table-land of Tibet, and part of Mongolia, form another rainless region in the great continent; while in the New World the rainless districts are the table-land of Mexico, part of Guatemala, California, and the region that extends from the western declivity of the Andes in Peru to the shores of the Pacific. It will easily be seen, by reference to Mr. Keith Johnston's Chart of Rains, that the prevailing winds are deprived of their vapour by condensation before arriving at these rainless deserts. The Kalahari desert in South Africa, and Australia, suffer from periodical droughts; but the periods of their occurrence are not yet ascertained. The Pampas of South America are also subject to droughts, though they are not periodical, nor do they last more than a season.

Between the tropics it rains rarely during the night, and for months together not a drop falls; while in the temperate zone it often rains in the night, and rain falls at all seasons, though more abundantly in some than in others. It seldom rains in summer throughout the N. of Africa, Madeira, the southern parts of Spain and Portugal, Sicily, southern Italy, all Greece, and the north-western part of Asia; but it falls copiously during the other seasons, especially during the winter; consequently that extensive region is called the province of winter rains. In the strictly western districts of Scotland, December, January, and February are the rainiest months.

The province of autumnal rains includes all Europe S. of the Carpathians, western France, the delta of the Rhine, northern and western Scandinavia, and the British Isles; throughout these countries more rain falls in autumn than in the other three seasons.

The province of summer rains comprises the eastern parts of France, the Netherlands (with the exception of the delta of the Rhine), the N. of Switzerland, all Germany N. of the Alps, the Carpathian mountains, Denmark, southern Scandinavia, all Central Europe, and the countries beyond the Ural mountains to the interior of Siberia, where showers are very rare in winter. In some places it rains almost perpetually, as in the island of Sitka, on the north-eastern coast of North America, where the year has sometimes passed with only 40 days of fair weather.

South Africa and Australia resemble each other in their rainy seasons, which in both countries are during the winter months.

The number of rainy days depends upon the direction of the wind. In Continental Europe, if the wind always blew from the N.E., it would seldom rain, because it blows over a great extent of continent; whereas it would never cease raining were the wind always to blow from the S.W., because it would ever come loaded with vapour from the Atlantic. Hence the greatest quantity falls on the west coasts of Great Britain and Ireland, the coast of Scandinavia, the Eastern Alps, and the centre of Portugal; in the two last it depends partly on the height and form of the mountains. In western Europe it rains on twice as many days as in the eastern part: in Ireland there are three times as many rainy days as in Italy or Spain. In fact, on the western side of Ireland it rains on 208 days out of the 365; in the Hebrides and west parts of Scotland perhaps still more. In England, France, and the north of Germany, there are from 152 to 155 rainy days in the year; the number decreases towards the interior of the continent, so that in Siberia it only rains on 60 days in the year. Occasionally it rains over a wide extent of country at the same time, on the 2nd of February, 1842, it rained in North America over 1400 miles in length, but the breadth to which it extended was not ascertained. Rain sometimes falls without visible clouds, from a partial condensation of vapour; Sir James C. Ross mentions a smart shower with a cloudless sky in the South Atlantic on the 20th December, 1839; it continued for an hour.

§ 4. When the temperature of the air is near the freezing-point or below it, snow falls instead of rain; but the colder the air the less moisture does it contain, consequently the less snow falls, which is the reason of the comparatively small quantity on the high plains of Tibet and of the Andes. Snow sometimes assumes the form of grains; but is generally in regular crystals of great beauty, varying in form according to the degree of cold. The late Dr. Scoresby, whose voyages in the Polar Seas afforded him constant opportunities of studying them, mentions five principal kinds of snow crystals, each of which had many varieties, in all amounting to 96. M. Kämtz, however, is of opinion that there are several hundred. The whiteness of the snow is owing to the reflection of light from the minute faces of its crystals, which are like so many small mirrors.

Snow never falls between the tropics except on the tops of very high mountains. The mean elevation of the line of perpetual snow above the level of the sea in these hot regions is about 15,207 feet, from whence it decreases on both sides, and at last grazes the surface of the earth at the arctic and antarctic circles, subject, however, to various flexures. In the Andes, near Quito, the lowest level has an elevation of 15,795 feet, which is higher than the top of Mont Blanc; from thence it varies very irregularly both to the N. and S. In 18° of N. lat. it descends to 14,772 feet on the mountains of Mexico, while on the S. it rises to 18,000 feet in some parts of the western Cordillera of the Bolivian Andes, owing to the extensive radiation and the ascending currents of heated air from the subjacent plains and valleys. The line is at an altitude of 17,000 feet on the western Cordillera, whence it sinks to 13,800 feet at Copiapo, to 12,780 near Valparaiso; it is only 7960 in the southern prolongation of the Chilian Andes, on the volcano of Antuco, lat. 37° 40′, and 3390 in the Strait of Magellan. In lat. 31° N. the snow-line is at an elevation of 12,980 feet on the southern side of the Himalaya, and at 16,620 feet on the northern side, while Captain Gerard gives from 18,000 to 19,000 as its altitude on the mountains of the Tibetian table-land N. of the upper valleys of the Indus and Sutlej. On Mont Blanc the line is at the height of 8500 feet; so that mountain is snow-clad for 7000 feet below its summit. In the Pyrenees it is at 8184 feet, and at the island of Mageroe, on the coast of Norway, it is at 2160 feet above the Polar Ocean.

In the southern hemisphere snow never falls on the low lands at the level of the sea N. of the 48th parallel of latitude, on account of the predominance of water, whereas in the northern hemisphere it falls on the plains in much lower latitudes, on account of the excess of land; but its limit is a curved line, on account of the alternations of land and water. In the western part of the great continent the southern limit of the fall of snow on the low lands nearly coincides with the 30th parallel of N. latitude, so that it includes all Europe. In the American continent it follows nearly the same line, extending through the southern parts of the United States. In China snow falls at the level of the sea as far south as Canton; on the north-western coast of America, on the contrary, it does not fall at that level till about the 48th degree of N. lat.—these are the two extremes. Although Europe lies within the region of snow, the quantity that falls is very different in different places, increasing greatly from S. to N. On an average it snows only one day and a half at Rome in the year, while at Petersburg there are 171 snowy days; but in that city the quantity of rain is to that of melted snow as 1000 to 384. Snow, by protecting the ground from cold winds, as well as by its slow conducting power and by preventing radiation, maintains the earth at a higher temperature than it otherwise would have. In Siberia the difference between the temperature of the ground beneath the snow and that of the air above it has amounted to 38° Fahrenheit.

Sleet, which is formed of small particles of rounded hail mixed with rain, falls in squally weather in spring and autumn. True hail, when large, is pear-shaped, and consists of a nucleus of frozen snow coated with ice, and sometimes with alternate layers of snow and ice. Hailstones have often fallen as large as the egg of a hen, or even that of a goose. The masses and blocks of ice of great size, which have not unfrequently fallen, appear to have been formed by the agglomeration of hailstones of large size frozen together; one the size of a millstone fell near Seringapatam, which it required three days to melt. It appears to be formed in the high cold regions of the atmosphere by the sudden condensation of vapour during the contention of opposing winds, and is intimately connected with electricity, since its fall is generally accompanied with thunder and lightning. Hail-showers are of short duration, exceedingly partial, and extend over a country in long narrow bands: one which took place on the 13th of July, 1788, began in the morning in the South of France and reached Holland in a few hours, ravaging a narrow line of country in its passage. On the 31st September, 1856, a strip of country near Florence was ruined during a violent thunder-storm by hailstones weighing 12 and 14 ounces.

Local circumstances, no doubt, have a great influence on the formation of hail: it occurs more frequently in countries at a little distance from mountains than in those close to them or farther off, and at all hours, but most commonly at the hottest time of the day, and rarely in the night. In the interior of Europe one-half of the hail-storms take place in summer. Hail is rare on the tropical plains, and almost altogether unknown; it falls at times at heights of 1700 or 1800 feet, and at still greater elevations,—in the Bolivian Andes, for example, above 13,000, and on the table-land of Ethiopia at heights between 6000 and 10,000 feet. The same has been observed in India, where hailstorms occur in the lower regions of the Himalaya and in the Neilgherries at elevations of 3000 and 6000 feet.[1] If the air is very cold throughout the greater part of the stratum through which hail falls, it is probably increased in size during its descent; and, on the contrary, large drops of rain which precede a thunder-storm are supposed to be hail melted in its passage through low warm air. Thus the thin impalpable air is the storehouse of vapours, and clouds, and storms, breathing softly over sea and land, and watering the earth with gentle showers at one time, and at another rushing with the fury of the hurricane, or heaving along the dark cloud with the thunder-bolt, the hail, and the torrent. It carries warmth to melt the winter snow, and cold to temper the summer heat; viewless as it is, it contains the solid matter which feeds vegetation, from the impenetrable forest of the equator to the lichen which so scantily covers the polar rocks, and on it every creature that exists on the land or in the waters depends for life, and heat, and nourishment.

LIGHT.[2]

§ 5. We know nothing of the size of the ultimate particles of matter, except that they must be inconceivably small. The air is only visible when in mass; the smallest globule of steam tells no more of its atoms than the immensity of the ocean; the minutest grain of sand magnified appears like the fragment of a rock—no mechanical division can arrive at the indivisible. Although the ultimate atoms are beyond the power of vision, chemical compounds show that the divisibility of matter has a limit, and that the particles have different densities; moreover, the cleavage of crystalline substances affords reason to believe that they have different forms.[1] Thus the reasoning power of man has come to the aid of his imperfect sense of vision, so that what were before imaginary things are now real beings with definite weights, and united by fixed laws. Though nothing had been known of their size, their effects were evident in the perceptions of sweet and sour, salt and bitter, and in the endless varieties of aroma in the food we eat and the liquors we drink. Every substance on earth is merely a temporary compound of the ultimate atoms, sooner or later to be resolved into its pristine elements, which are again to be combined in other forms, and according to other laws; so that literally there is nothing new under the sun, for there is no evidence of new matter being added to the earth, except in the case of meteorites, nor of that which exists being annihilated. Fire, which seems utterly to destroy, only resolves bodies into their elementary parts, to become what they were before, the support of animal or vegetable life, or to form

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[1] Buist on Hailstorms in India, in 'Transactions of Bombay Geographical Society,' vol. xii.

[2] The celestial regions are filled with an extremely rare and highly elastic medium or ether, whose particles are capable of receiving the

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vibrations communicated to them by self-luminous bodies, and of transmitting them to the optic nerves of the eye, so as to produce the sensation of light. The intensity of light depends upon the extent of the vibrations of the particles of ether, while its colour depends upon their frequency. Heat, like light, is a vibration of the particles of ether; they are both forces, and act as such. In fact, heat is merely a force of expansion, which increases the distance between the particles of a body till it is balanced by their mutual attraction, and in that state it is insensible to the thermometer, but it becomes sensible by compression. Thus the heat in the air may be squeezed out so as to ignite tinder; consequently it is *changed into light*. Hence *latent heat* and *caloric* are no longer admissible terms, for the former is a *force of expansion*, and the latter is simply a *force*. It is now proved beyond a doubt that light, heat, chemical action, electricity, and magnetism, are forces, or rather powers, subject to dynamical laws, and that they are correlative, or that they mutually produce or merge into one another. Thus heat produces electricity, and electricity produces heat; chemical action produces light, and light produces chemical action, &c. All are correlative with one another or with motion; nevertheless, they can only act on one another through the medium of matter which is permeable to the ether. It is evident that the idea of electricity and magnetism being fluids must be rejected; they are *powers*, and act on matter as such.—See the 'Connexion of the Physical Sciences,' by Mary Somerville.

[1] The reader is referred to the 'Connexion of the Physical Sciences' for an account of Dalton's theory of definite proportions, and the relative weight of atoms; and to Dr. Daubeny's work on the Atomic Theory.

new mineral compounds. It is to the action of these particles on the light of the sun that nature owes all its colours.

When a sunbeam passes through a glass prism,[1] an oblong image of it is formed, consisting of colours in the following order: red, orange, yellow, green, blue, indigo, and violet. Sir John Herschel discovered lavender rays beyond the violet, and dark red rays exterior to the red, which are not so easily brought into evidence as the rest.

Even the most transparent substances absorb light; air, water, the purest crystal, arrest some of the rays as they pass through them. A portion of the light is also reflected from the surface of all bodies; were it otherwise, they would be invisible. We should be unconscious of the presence and form of material substances beyond our reach except by the reflected rays,—

> "The mist of light from whence they take their form
> Hides what they are."

As the same light does not come to all eyes, each person sees his own rainbow, the same flower by different rays. White substances reflect all the light, black substances absorb all but that which renders them visible, while coloured bodies decompose the light, absorb some of the colours, and reflect or transmit the rest. Thus a violet absorbs all but the violet rays, which it reflects; a red flower only reflects the red and absorbs the rest; a yellow substance absorbs all but the yellow. In the same manner transparent substances, whether solid or fluid, absorb some colours and transmit others: thus an emerald absorbs all but the green, a ruby all but the red; whereas a diamond does not decompose the light, but transmits every ray alike. Very few, however, of the colours, whether transmitted or reflected, are pure, but the substance takes its hue from the colour that predominates.

The atmosphere, where rarefied, absorbs all the colours of the sun's light except the blue, which is its true colour.[2] In countries where the air is pure, the azure of the sky is deep; it is still more so at great elevations, where the density of the air is less; and its colour is most beautiful as it gradually softens the outlines of the mountains into extreme distance, or blends the sea with the sky. When the sun is near the horizon, the atmosphere, on account of its superior density, absorbs the violet and blue, and leaves the yellow and red rays in excess; that property, together with the refractive

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[1] The reader is referred to the 18th section of the 'Physical Sciences' for reflection, refraction, and absorption of light, and to the 19th section for the constitution of the solar light and colours.

[2] Professor Tyndall has proved that the blue colour of the sky is owing to the reflection of the blue rays of the sun by infinitessimal particles of aqueous vapour floating in the highest regions of the atmosphere.

power of the aqueous vapour, which is most abundant near the earth's surface, gives the roseate hue to the early morning, and the gold and scarlet tints to the closing day. The blending of these colours with the blue above produces that beautiful vivid green so frequently seen in Italy and other warm countries. The last reflected rays of the setting sun are red, which gives a rose-coloured tint to the Alpine snows, and below the red the shadow of the earth is sometimes cast upon the atmosphere in the form of a deep blue segment, known as the ante-twilight. The air reflects and scatters part of the white solar beams, whence the brightness and cheerfulness of day; were it not for that reflective power, the sun and moon would be like sharply defined balls of fire in the profoundly black vault of the heavens, and dark night would instantly follow sunset. When the sun is 18 degrees below the horizon, the air, at the height of 30 miles, is still dense enough to reflect his rays, and divide the day from the night by the sober shades of twilight. Between the tropics twilight continues from the setting of the sun till he is 16 degrees below the horizon, in middle latitudes until he is 18 degrees, and in the polar regions until he is 20 degrees; then and then only does real night begin: at Edinburgh there is no real night from the 6th of May until the 7th of August, in London there is none from the 21st of May till the 22nd of July, and in Paris there is no true night in the month of June.

A considerable portion of the sun's light is absorbed by the atmosphere: the loss increases with the obliquity of incidence and the density of the air. It is diminished 1300 times by the thickness of the air at the horizon, which enables us to look at the sun when setting without being dazzled.[1]

§ 6. The bending or refraction of the sun's light passing through the atmosphere causes distant objects, as mountains, to appear higher than they are. It increases with the density of the air and the obliquity of incidence, and on that account the sun is seen above the horizon after he is really below it, or has set, and also before he has really risen. During the winter of 1820, which the expedition under Sir Edward Parry passed at Melville Island, in 70° 47′ N. lat., the sun did not rise for 92 days; but in consequence of extraordinary refraction he appeared above the horizon on the 3rd of February, which was three days sooner than he ought to have done, unaided by refraction.

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[1] The photometer is an instrument invented by the late Sir John Leslie for measuring the relative intensity of light and its variations, upon the principle that the heat contained in solar light is a measure of the intensity of light. Sir John computed that one-fourth of the light of the sun is absorbed by the atmosphere, and, with regard to obliquity of incidence, that, out of 1000 rays which fall obliquely on the earth, only 378 reach it at the equator, 288 in the latitude of 45°, and 110 at the poles; in England the light measured by the photometer is 65° greater in intensity in summer than in winter.

Professor Secchi says that Leslie's photometer is now acknowledged to be a simple thermometer: as light can be said to be efficient on earth as accompanied by heat and chemical action, so the measures by the photometer of Leslie, or actinometer, are very useful, but they should be accompanied also by a study and researches on chemical action, which until lately were omitted. The observations of Professors Rouse and Bunsen on the diurnal and annual variation in the actinic power of light promise to add much to our knowledge on this subject.

The sun and moon often appear distorted at their rising and setting, because the looming, or extraordinary refraction, is greatest in the morning or evening, from the increased density of the air at the surface of the earth by reason of the cold. This distortion of objects is occasioned by the rays of light passing through strata of air of different densities; from this cause objects are sometimes seen inverted, and three images of the same object occasionally appear, two direct and one inverted.

Mirage, or the delusive appearance of water, so frequent in deserts, is owing to the reflection of light between two strata of air of different densities, occasioned by the radiation of heat from the arid soil. It is very common on the extensive plains of Asia and Africa, and especially in Upper Egypt; villages on small eminences above the plain appear as if they were built on islands in the middle of a lake when the dry sandy ground is heated by the mid-day sun. Sometimes objects appear double, and occasionally several images appear above one another, some direct and some inverted; this is particularly the case in high latitudes, where the Icy Sea cools the the stratum of air resting on it.[1]

In the polar regions, or on the tops of mountains, when the sun is on or near the horizon, the shadow of a person is sometimes thrown on an opposite cloud or mist, the head being surrounded by concentric coloured rings or circles, the number varying from one to five. Dr. Scoresby saw four of these rings, on one occasion, round the shadow of his head, as he stood between the sun and a thick low fog: the first ring consisted of concentric bands of white, yellow, red, and purple; the second consisted of bands of blue, green, yellow, red, and purple; the third of green, white, yellowish white, red, and purple; and in the fourth the bands were greenish white, deeper on the edges. Mr. Green, at the height of two miles, saw the shadow of his balloon, surrounded by three coloured rings, on a cloud below. These appearances, called *glories*, or fog-images, and the coronæ, or small concentric coloured circles which surround the sun or moon when partly obscured by thin white clouds, are owing to the refraction of the light in the aqueous particles of the cloud or fog. The colours in the concentric bands of the coronæ, however, differ from the foregoing; that nearest the sun is of deep blue, white, and red; the circle exterior to that consists of purple, blue, green, pale yellow, and red; but the series is very rarely complete.

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[1] For the cause of mirage, see the 'Connexion of the Physical Sciences.'

Halos, which surround the sun in large circles, or a complicated combination of circles, are, on the contrary, supposed to be produced by the light falling on minute crystals of ice suspended in the atmosphere; they are particularly brilliant and frequent in high latitudes. It is scarcely possible to give an idea of these beautiful and singular objects. Sometimes a large coloured circle surrounds the sun or passes through his centre, which is occasionally touched or cut by segments of others. One seen at St. Petersburg on the 29th of June, 1790, consisted of four coloured circles of different sizes intersecting each other, which were either cut or touched by segments of eight others, and at the points of intersection mock suns or parhelia appeared. The sky is very hazy on these occasions. Mock suns, without circles and halos, are by no means uncommon, and halos are often seen round both sun and moon, but seldom of that complicated kind. They are situate between the observer and the sun, whereas the rainbow is always in that part of the sky opposite the sun, because it is produced by refraction and reflection of the sun's rays in the drops of rain; and when the light is intense and the rain abundant, there are two concentric bows, the prismatic colours of the innermost of which are the most vivid, the violet being within and the red outside: sometimes the inner edge exhibits a repetition of colours in fine fringes, in which red and green predominate. The colours are reversed in the exterior bow, the violet being outside and the red on the inner edge. Besides these two principal and most common bows, supernumerary rainbows occasionally appear within the interior bow, generally green and violet, though they are sometimes more or less perfect repetitions of all the colours.[1] The visible extent of the bow depends upon the altitude of the sun and the position of the spectator. As a line joining the centres of the sun and bow must pass through the eye of the spectator, the altitude of the sun must be less than 45°, and only a portion of the bow can be seen from a plain; but the complete circle may be visible to a person on the top of a high mountain when the sun is low, except the small portion intercepted by his shadow. In squally weather a rainbow is sometimes seen on a blue sky when rain is falling, but it is generally on clouds; it is constantly seen when the sun shines on the fine drops of fountains and cascades, and on the grass in a dewy morning. As the light of the moon is feeble, lunar rainbows are rare, and, for the most part, colourless. In the early morning, when the sun throws his slanting beams across the fields, a miniature bow, with all its vivid colours, may be seen in each dewdrop as it hangs on the points of the bending grass.

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[1] In the primary bow the light is twice refracted and once reflected in the rain-drops, while in the external bow it is twice refracted and twice reflected; and as light is lost at each refraction and reflection, the interior bow is the brightest. Sir David Brewster found that the light of the rainbow is polarized.

§ 7. Light is said to be polarized when, after having been once refracted or reflected, it is rendered incapable of being again refracted or reflected at certain angles. For example, if a crystal of brown tourmaline be cut longitudinally into thin slices, and polished, the light of a candle may be seen through a slice as if it were glass. But if one of these slices be held perpendicularly between the eye and the candle, and a second slice be turned round between the eye and the other plate of tourmaline, the image or the candle will vanish and come into view at every quarter-revolution of the plate, varying through all degrees of brightness down to total or almost total evanescence, and then increasing again by the same degrees as it had decreased. Thus the light, in passing through the first plate of tourmaline, is said to be polarized, because it has been rendered incapable of passing through the second piece in certain positions.

A ray of light acquires the same property if it be reflected from a pane of plate-glass at an angle of 57°; it is by that rendered incapable of being reflected by another pane of plate-glass in certain definite positions, for the image of the light vanishes and reappears alternately at every quarter-revolution of the second pane.

If a thin plate of mica be interposed when the image of the candle has vanished, the darkness will instantly disappear, and a succession of the most gorgeous colours will come into view, varying with every inclination of the mica from the richest reds to the most vivid greens, blues, and purples. The most splendid colours arranged in symmetrical forms are exhibited by thin plates of an infinite variety of substances besides mica. They display some of the most beautiful objects in nature, and show differences otherwise inappreciable in the arrangement of the molecules of crystalline bodies.[1]

Arago discovered that the light of the sun is polarized by the reflection of the atmosphere, but not equally so on every part of the sky; the polarization is least in the vicinity of the sun, and greatest at 90° from him, for there his light is reflected at an angle of 45°, which is the polarizing angle for air.[2] There are three points in the sky where the light is not polarized: one of these neutral points, discovered by M. Arago, is 18° 03′ above the point diametrically opposite to the sun when he is in the horizon; the second neutral point, discovered by M. Babinet, is 18° 30′ above the sun when he is rising or setting; and the third, discovered by Sir David Brewster, is 15° or 16° below the sun. These points vary with the height of the sun, and the two latter rise and coincide in his centre when he is in the zenith.[1]

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[1] For phenomena and theory of polarized light, see section 21, 'Connexion of the Physical Sciences.'

[2] Every substance, whether solid or fluid, has its own polarizing angle.

Now the portion of polarized light sent to the eye from any part of a clear sky is in a plane passing through that point, the eye of the observer, and the centre of the sun. If that point be the N. pole of the heavens, it is clear that, as the sun moves in his diurnal course, the plane will move with him, as an hour circle, and may be used as a dial to determine the hour of the day. Professor Wheatstone, by whom that beautiful application of the polarization of the atmosphere has been made, has constructed a clock, of very simple form, which shows the time of day with great accuracy, and which has many advantages over a sundial.

ELECTRICITY.

§ 8. Electricity pervades the earth, the air, and all substances, without giving any visible sign of its existence when in a quiescent state, but, when elicited, it exhibits forces capable of producing the most sudden, violent, and irresistible effects. It is roused from its dormant state by every disturbance in the chemical, mechanical, or calorific condition of matter. There are two kinds of electricity, positive and negative.[2] When bodies have different kinds of electricity they attract each other, and, when not opposed, the electricity coalesces with great rapidity, producing the flash, explosion, and shock, and that with the more violence the greater the tension or pressure of the electricity on the surrounding air which resists its escape. Equilibrium is then restored, and the electricity remains quiescent till called forth by a new exciting cause. When similarly electrified they repel each other. The electrical state of substances is easily disturbed, for, without contact, positive electricity tends to produce negative electricity in a body near it, and *vice versâ:* the latter is then said to be electric by induction.

The electricity of the atmosphere arises from evaporation, condensation, and the chemical changes that are in perpetual progress on the earth's surface; no electricity, however, is developed by the evaporation of pure water, but it arises abundantly from water containing matter susceptible of chemical action during the evaporation; consequently the ocean is one of the greatest sources of atmospheric electricity; it ascends with the vapour into the higher regions of the atmosphere, where there is always a great quantity of positive electricity, which, like the magnetism of the atmosphere, increases with the diminished temperature, and accounts for the violent electrical explosions on the high plains of the Andes; and the Acroceraunian mountains have obtained their name from the frequent thunder-storms to which they are liable. Combustion is another source, and a large portion arises from vegetation. The air, when pure, is almost always positively electric; but as the chemical changes on the earth sometimes produce positive and sometimes negative electricity, it is subject to great local variations; a passing cloud or a puff of wind produces a change, and a distant storm renders it negative for the time, but the earth is always in a negative state. The quantity of electricity varies with the hours of the day and the seasons; it is more powerful in the hours after sunset, from which it becomes less as the night advances, in winter than in summer, and it diminishes from the equator to the poles. It thunders daily in many places, in others never, as on the E. coast of Peru and in the Arctic regions, except where there are violent volcanic explosions, which always generate electricity, as in Iceland. Wherever there are no trees or high objects to conduct it to the ground, the quantity of positive electricity increases with the height above the surface of the earth. Violent thunder-storms take place on the highest summits of the Andes and Himalaya mountains. La Condamine encountered a violent thunderstorm on a peak of the Cordilleras at the height of 15,970 feet. On the high table-land of Ethiopia they are violent, and so frequent, that M. d'Abbadie calculates it thunders fifty-six days out of every hundred. In general, thunder-clouds in our latitudes float at the height of from 3000 to 5000 feet above the earth, though observers on the summit of hills, less than a quarter of a mile in height, have seen thunder-showers below them.

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[1] The reader is referred to a plate in Johnston's folio Physical Atlas showing the phenomena of the polarization of the atmosphere.

[2] See sections 28 and 29 of the 'Connexion of the Physical Sciences;' on Electricity.

Electricity becomes very strong when dew is deposited, especially after sundown, and in some cases it is strongly developed in fogs. Mr. Cross found it so powerful on one occasion, that it was dangerous to approach the apparatus for measuring its intensity. A continued succession of explosions lasted nearly five hours, and the stream of fire between the receiving-ball and the atmospheric-conductor was too vivid to look at. M. Peltier has found that the common fogs arising from the mere condensation of the moisture in the air are neutral, but that others which are produced by exhalations from the earth are sometimes positive, sometimes negative; the subject, however, requires further investigation.

Though in long-continued mild rains there are no traces of electricity, yet when rain or snow falls from the higher regions of the atmosphere it is more or less developed, sometimes positive, sometimes negative, depending a good deal on the direction of the wind. During a shifting fall of snow Mr. Cross elicited electricity enough to decompose water. The atmosphere being positively electric, negative rain is supposed to arise from the evaporation of the drops in passing through dry air; the vapour carries off the positive electricity and leaves the drop in a negative state—a circumstance which seems to be confirmed by the electricity of cascades, near which there always is more or less negative electricity; the positive is conducted into the earth, while the other remains united to the drops of the cascade.

The inductive action of the earth upon the clouds, and of the different strata of clouds on each other, produces great variations in their electrical state. If rain falls from the lowermost of two strata of positively electrical clouds, the inductive action of the earth renders the under surface positive and the upper negative, and the rain is positive. By-and-by the under surface of the cloud and the earth become neutral; and after a time the lower cloud becomes charged with negative electricity by the induction of the upper strata, and the rain is then negatively electric. Clouds are very differently charged; and when clouds differently charged meet, an explosion takes place. When the sky is clear and the air calm and warm, a succession of small white fleecy clouds rising rapidly above the horizon and flying swiftly in the very high regions of the atmosphere, is a certain presage of a thunder-storm.

Electricity of each kind is probably elicited by the friction of currents of air, or masses of clouds moving rapidly in different directions, as in thunder-storms, when small white clouds are seen flying rapidly over the black mass; yet the quick and irregular motion of clouds in storms is probably owing to the strong electrical attraction and repulsion among themselves, though both may be concerned in these hostile encounters. When two clouds differently charged by the sudden condensation of vapour, and driven by contending winds, approach within a certain distance, the thickness of the coating of electricity increases on the two adjacent sides; and when the accumulation becomes so great as to overcome the coercive pressure of the atmosphere between them, a discharge takes place which occasions a flash of lightning. The actual quantity of electricity in any part of a cloud is very small. The intensity of the flash depends upon the extent of surface occupied by the electricity, which acquires its intensity by its instantaneous condensation.

The air, being a non-conductor, does not convey the electricity from the clouds to the earth, but the latter acquires from them an opposite electricity, and when the tension is very great the force of the electricity becomes irresistible, and an interchange takes place between the clouds and the earth, but the motion of the lightning is so rapid that it is difficult to ascertain when it goes from the clouds to the earth, or from the earth to the clouds, though there is no doubt it does both: explosions have burst from the ground, and people have been killed by them. During the Canadian expedition of 1857, Captain Palliser states that he frequently observed, while on Lac la Pluie and elsewhere, that the lightning flashed upwards from the earth to the impending cloud, when it often presented the appearance of a string of bright beads.

When the quantity of electricity developed by the sudden condensation of vapour is very great, the lightning is always forked; its zigzag form is ascribed to the compression of the air before the electricity, thereby opposing greater resistance, and turning the fluid aside to seek some path upon which the resistance is less. The author once saw a flash divided into four parallel streams—a very uncommon occurrence. Occasionally in very great storms the lightning sends off lateral branches. It often appears as a globe of fire moving so slowly that it is visible for several seconds, while the flashes of forked lightning do not last the thousandth part of a second, but the impression on the eye lasts much longer. Professor Wheatstone, who has measured the volocity of lightning by experiments of great ingenuity, found that it far surpasses the velocity of light. This velocity is beautifully exemplified in the electric telegraph, by which the most violent and terrific agent in nature is rendered obedient to man, and conveys his thoughts with extreme rapidity. The colour of lightning is generally a dazzling white or blue, though in highly rarefied air it is rose-colour or violet. The light given out by a flash of lightning is produced by the incandescence of the particles of the air through which the current of electricity passes, the oxygen, nitrogen and moisture present being converted into certain compounds, such as nitric acid and ammonia. The light seen is therefore not the electricity itself, which being pure force is perfectly invisible, but simply the effect of it.

When the air is highly rarefied by heat its coercive power is diminished, so that the electricity escapes from the clouds in the form of diffuse lambent sheets, without thunder or rain, frequently seen in the warm summer evenings, sometimes near the zenith, and quite different from that sheet lightning at the horizon, which in general is only the reflection of the forked lightning of a distant storm. The author saw a very remarkable instance of that glow-discharge from a terrace at a considerable height above Turin. Vineyards descended rapidly to the plain on one side, and a crescent of hills rose on the other. It had thundered off and on the whole day; in the evening the heat was great and the darkness intense, but brilliant flashes of lightning momentarily illuminated the valleys of the Po and Dora, and the magnificent chain of Alps that bounds them. By degrees the lightning became less frequent, and at last ceased. The air was perfectly still, and the darkness extreme, when a silvery blue light appeared in the Val de Susa, as if the moon had been rising; it spread over a great part of the Alps, along the tops of the crescent of hills behind the terrace, and then a large column of it rose from the vineyards immediately below, and close to the terrace, which made the surrounding objects visible. There was no noise; and in ten minutes it vanished, but in about a quarter of an hour the phenomenon was repeated exactly in the same manner, lasted about the same time, and was followed by a torrent of rain.

The sudden compression of the air during the passage of lightning must convert a great quantity of heat of expansion into sensible heat, for heat exists in all bodies independent of their temperature. Heat is absorbed and becomes insensible to the thermometer when solids become liquids, and when liquids are changed to vapour; and it again becomes sensible when vapour is condensed, and when liquids become solids. When water freezes, all the heat that kept it liquid is given out; and when ice melts, it absorbs heat from everything near it. The air is full of absorbed heat, whatever its temperature may be, but it can be squeezed out by sudden compression so as to kindle tinder. Every aërial wave, every sound, every word spoken must set free an infinitesimal quantity of heat; so everything that tends to rarefy the air must cause it to absorb a proportional quantity.

Thunder is considered to be the result of the sudden re-entrance of the air into a void space, caused by the lightning in its passage through the air. The electrical force communicates a powerful repulsive force to the particles of air along the path of its discharge, producing thus a momentary void, into which the air rushes again with a force proportioned to that which caused the separation. The rolling noise of thunder is evidently owing to the difference between the velocity of lightning and that of sound. The clouds at different distances giving rise to a series of echoes which reach the ear at irregular intervals. Thunder may be regarded as originating in every point of a flash of lightning at the same instant; and as sound takes a considerable time to travel, it will arrive first from the nearest point; and if the flash run in a direct line from a person, the noise will come later and later from the remote points of its path, in a continued roar. Should the direction of the flash be inclined, the succession of sounds will be more rapid and intense; and if the lightning describe a circular course above a person, the sound will arrive at the same instant from every point with a stunning crash.[1] The rolling is also partly the result of echoes.

In passing to the earth, lightning follows the best conductors—metals by preference, then damp substances—which is the reason why men and animals are so often struck. If it meets with a bad conductor it shivers it to pieces, and scatters the fragments to a considerable distance. A powerful flash scatters gunpowder, while a feeble one ignites it; the hardest trees are split and torn to shreds; when a tree is struck, the heat of the flash converts the sap into steam, the expansive force of which shivers the tree. The surface of rocks is vitrified by it: and when it falls on a sandy soil, its course under ground is marked vitrifying the sandy particles, and forming of them tubes many feet long.

Where the trade-winds blow, thunder-storms are hardly known, though electric discharges are frequent in the zones of calms, at their limits. At the change of the monsoons masses of black clouds roll over the sky, the darkness is reflected from a calm sea, dead stillness and silence prevail till the "thunder utters his voice," and the war of the elements begins—terrible on land, but terrific in a ship far at sea.

In Greece and Italy there are about 40 thunder-storms annually, which occur in spring and autumn, while N. of the Alps they chiefly take place in summer. There are about 24 in the year on the coasts of the Atlantic and in Germany, but they are much more frequent among mountains than on plains. In the interior of the old continent they rarely occur in winter, and three-fourths of the number happen in summer. In Lower Peru, where it never rains, thunder is never heard. Thunder-storms are of such rare occurrence in high latitudes, that, in a residence of six years in Greenland, Geiseke only heard it thunder once.

Some storms arise from the contention of opposite currents in the air; others are occasioned by currents of warm air ascending from the earth, wich are suddenly condensed as they enter the upper regions of the atmosphere, and, as this sometimes happens at the hottest hour of the day, these storms are periodical for many successive days, recurring always at the same hour. Volcanic eruptions, whirlwinds, and waterspouts, which cause the moving of vast masses of air and the rapid condensation of vapour, are also generally attended by thunder and lightning. Sometimes they extend over a great expanse of country, and the lightning darts from all points of the compass. A person may be killed at the distance of 20 miles from the explosion by the *back stroke*. If the two extremities of a highly charged cloud dip towards the earth, they will repel the electricity of the latter, if it be of the same kind with their own, and will attract the other kind; and if a discharge should take place at one end of the cloud, the equilibrium will instantly be restored by a flash from that part of the earth which is under the other, sufficiently strong to destroy life; the back stroke is the most dangerous, though never so strong as the direct one.

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[1] Sound travels at the rate of 1120 feet in a second in air at the temperature of 62° of Fahrenheit; so, if that number be multiplied by the number of seconds elapsed between the flash of lightning and the thunder, the result will be the distance in feet at which the stroke took place. A relative of the author's was fishing in the Tweed on a very sultry day, and lay down on the grass to rest: he was astonished to hear repeated peals of thunder, as there was not a cloud to be seen in the sky; two hours afterwards clouds began to rise, and in the afternoon there was a thunder-storm; the sound had been conveyed down the river by the stream.

When thunder-clouds are very low, there is frequently no lightning; the electricity produced by induction is so powerful that it escapes from pointed objects in the shape of flame, known as St. Elmo's fire. These flames are not unfrequently seen at the topmasts of ships and the extremities of their yards. Bodies between the clouds and earth may be electricized by induction, and their electricity will be seen in the form of flame, as showers of phosphorescent snow.

Phosphorescence is ascribed to electricity; various substances emit light when decaying, as fish and wood. Many marine animals are phosphorescent, and the luminous appearance which the sea sometimes assumes is principally to be attributed to this cause, although in some localities the slow combustion of the phosphorus in the decaying animal matter it contains may in a slight degree contribute to it.

MAGNETISM.

§ 9. Magnetism is one of those molecular forces which, like electricity and heat, are known only by their effects. It is evidently identical with electricity, the two forms of force being readily convertible into each other.

The action of terrestrial magnetism upon the magnetic needle is extremely complicated; the direction of the force horizontally is determined by the declination-needle, or mariner's compass, and vertically by the dipping-needle: they consist of magnetised needles, or bars of steel, so suspended that the declination-needle revolves in a horizontal direction, and the dipping-needle in a plane perpendicular to the horizon. The variations of magnetic force are determined by comparing the squares of the numbers of vibrations made by the dipping-needle in a given time.

The N. end of the dipping-needle sinks or dips below the horizon in the northern hemisphere, the S. end sinks or dips beneath it in the southern hemisphere, and between the two there is a line which encircles the whole earth, where the dipping-needle remains horizontal. That line, which is the magnetic equator or line of no dip, crosses the terrestrial equator in two places; one lies a little to the E. of the meridian of Greenwich, and the other in 170° E. long.: it extends alternately on each side, but never deviates more than 12° or 15° from it. N. and S. of the magnetic equator the needle dips more and more, till at last it becomes perpendicular to the horizon in two points, or rather spaces, known as the N. and S. magnetic poles, which are quite distinct from the poles of the earth's rotation. One, whose position was determined by the late Sir James Ross, is in 70° N. lat. and 97° W. long., while that in the southern hemisphere is placed by the same celebrated navigator, from his observations in 1841 in the interior of Victoria Island, in 75° 5′ S. lat., and 154° 8′ E. long. Lines of equal dip are such as may be drawn on a globe through all those places where the dipping-needle makes the same angle with the horizon. The mean dip for Great Britain in 1860 was fixed by General Sabine at 68° 59′. The maximum dip for the same year was found to be 71° 29′ 5″ at Jordan Hill, near Glasgow, the minimum at St. Leonard's being 67° 44′ 5″.

The magnetic meridian is the mean direction which a freely suspended horizontal needle assumes when left to itself. The magnetic meridians coincide with the geographical meridians in some places, and in these the magnet points to the true N. and S., that is, to the poles of the earth's rotation. But if it be carried successively to different longitudes, it will deviate sometimes to the E., sometimes to the W., of the true N. Imaginary lines on the globe, passing through all places where the needle points to the poles of the earth's rotation, are lines of no variation; and lines passing through all places where it deviates by an equal quantity from the geographical meridians, are lines of equal variation; they are also very irregular, and form two closed systems, or loops—that is, they surround two points, one in North Siberia, and another in the Pacific, nearly in the meridian of the Pitcairn Islands and the Marquesas.[1] The variation of the needle from the true N. in 1864 was 20° 45′ W.

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[1] The author is indebted to the investigations of General Sabine for almost all her information on the subject of terrestrial magnetism. In these, and in his notes to the English translation of Humboldt's 'Cosmos,' the reader will find the foundation of all that is most interesting on the

The intensity of the magnetic force is as variable and even more complicated than the other magnetic phenomena. From observations made in various parts of the earth it has been determined that there are four points in which the intensity is greater than anywhere else. Two of these are in the northern and two in the southern hemisphere; they neither coincide with the poles of the earth's rotation nor with the magnetic poles, nor are they all of equal intensity.

One of these foci of maximum magnetic intensity is situate in N. America, S.W. from Hudson Bay; another is in northern Siberia, in 120° E. long. In the southern hemisphere, one of the points of maximum magnetic intensity is in the S. Atlantic, in 20° S. lat. and 324° E. long., and the other is situate in 60° S. lat. and 131° 20′ E. long. In consequence of the unequal intensity of the force in these four foci, the decrease in magnetic power from them towards the equator is extremely irregular, so that the dynamic equator, which is a line supposed to be drawn through all the points of the earth where in each geographical meridian the intensity is the least, encircles the globe in a waving line, which coincides with neither the geographical nor magnetic equator; it forms the division between the magnetic intensities in the two hemispheres. The foci are all of different intensities; that in the S. Atlantic, discovered by M. Erman, has the least intensity of the four, and the other in the southern hemisphere, discovered by Sir James Ross, has the greatest; taking 1 as the unit at the magnetic equator in Peru, as determined by Humboldt, their intensities are as 2·071 and 0·706. In the northern hemisphere the American focus is more intense than that in Siberia, which is moving from W. to E., while the minor focus in the southern hemisphere is moving from E. to W. Lines drawn on a globe through all the points where the magnetic intensity is the same are

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subject. In his own works there are plates of the course of the different magnetic curves mentioned in the text. The most practically useful element of terrestrial magnetism, the declination or variation, has of late years formed an important object of observation by the officers of our navy. A vast number have been accumulated from every quarter of the globe, at the Hydrographical Office, where they are discussed, and laid down on the charts issued by the Admiralty, by a very talented officer, Mr. Evans; a most important service conferred on the navigators of every country by the late and present hydrographers of the navy. The British Association Reports and the Philosophical Transactions are from time to time full of interesting observations of magnetic phenomena. For those who wish to pursue the subject further, General Sabine's Memoir on the observations taken at Kew and Nertschink, 'Phil. Trans.,' 1864, and Dr. Balfour Stewart's Lecture on this subject in the Proceedings of the Royal Institution for 1864, may be consulted with profit.

so complicated that it is scarcely possible to convey an idea of them in words. They form a series of ovals round each of the foci of maximum force in each hemisphere. In the northern hemisphere they form the figure of 8, having a focus and its ovals in each loop; then they open into tortuous lines which encompass the globe, but which become less tortuous as they approach the dynamic equator. The complication is increased by the foci in the two hemispheres being unsymmetrically placed with regard to one another, as well as by the difference in their intensities. The measurement of magnetic intensity by British observers is referred to an absolute unit of measurement, that determined by Humboldt being purely arbitrary. The British absolute unit is an amount of magnetic force capable of moving one grain of matter through the space of one foot in one second of time. The magnetic intensity at London in 1864 was 10·29, *i.e.*, it was equal to a force that would move a mass of matter, weighing one grain, through 10·29 feet in one second. The minimum of magnetic intensity yet measured would be 6·4, the maximum 15·8. The minimum of magnetic intensity for Great Britain, as measured by General Sabine in 1860, was 10·626, at Fern Tower, near Crieff, situated in 56° 22′ N. lat., and 3° 50′ W. long.; the minimum measured at St. Leonard's-on-Sea was 10·225, and the mean of a large number of observations made in various districts 10·332. He also found that the lines of magnetic intensity ran due E. and N., seeming to follow the isothermal very closely. The lowest minimum of magnetic force, as observed by A. Erman, was at 19° 59′ S. lat. and 10° 2′ E. long., counting from Paris. The intensity increases as it approaches the four maximum points.

Thus it appears that there are six points on the earth which form as it were centres of magnetic force, all of which are distinct from one another and from the poles of the earth's rotation: namely, two magnetic poles, where the dipping-needle is at an angle of 90 degrees with the horizon, and four points which are the foci of magnetic intensity—that is, where the total magnetic force is a maximum. There are also two remarkable lines which encompass the earth, neither of which coincides with the geographical equator: namely, the magnetic equator, in every point of which the angle of the dip is zero: it encircles the earth and intersects the terrestrial equator;—the dynamical equator, or line of minimum magnetic intensity, which surrounds the earth in an irregular line, but neither coincides with the terrestrial nor magnetic equator; besides these, there is a zone which is supposed to pass through all places where the horary variations of the magnet partake of the phenomena of each hemisphere alternately; it either partly or nearly coincides with the line of minimum intensity.

Complicated as the magnetic phenomena are, they are rendered still more so by the secular periodic and occasional variations to which they are liable. The foci of maximum intensity and the whole system of the magnetic curves are moving along the two hemispheres in different directions; those in the northern in a direction from W. to E., and those in the southern from E. to W.; and as the foci of greatest intensity move with different velocities, the forms, as well as the positions, of the curves are rapidly and ceaselessly changing, so that in the course of a few years the whole magnetic system is altered. General Sabine, so profoundly versed in this branch of science, which has assumed a new character from his researches, has shown that the weaker magnetic focus in the northern hemisphere has moved through 100 degrees of longitude in 150 years. It is now in Siberia, in about the 120th eastern meridian, and is moving eastward toward America, while the American pole has been moving, but far more slowly, in the same direction since the year 1678. The poles seem to increase in magnetic force the nearer they approach to one another, and the intensity is also increased in the space between them. Hence in the northern hemisphere the effect of the secular easterly motion of the weaker magnetic pole is to increase the magnetic dip and force to the E. of the 120th meridian and to diminish them to the W. of it. For example, at Toronto in Canada, the total force has a secular increase of ·0052 annually, and the dip or inclination, which was 75° 17′·63 in 1840, has an annual increase of 1′·0. Moreover, the declination has a secular westerly increase, the rate of which is augmenting, for, at the end of 1851 the mean annual increase was 1′·952, at the end of 1854 it was 2′·54, and at the end of 1855 it was 3′·4. On the contrary, the total force is decreasing in Europe, and at London there is an annual decrease of 2′·7 in the inclination, and of 7′ in the declination westerly.

In the southern hemisphere the force is greater in the principal pole than in the pole of maximum intensity in the northern, probably because the foci of maximum force are only 90 degrees apart, while in the northern hemisphere they are 150 degrees. In the southern hemisphere the secular fluctuations are in an opposite direction to those in the northern. At St. Helena the declination has increased during the last 200 years at a nearly uniform rate of eight minutes annually. It takes place in equal aliquot portions in each of the twelve months; whence General Sabine infers that the secular changes must proceed from causes which act with surprising uniformity and regularity through a long succession of years. The laws and causes of these secular variations are unknown; their discovery is reserved for future generations, who will have the advantage of the most extensive and perfect system of observation that has ever been made on the state of terrestrial magnetism, and the charts which represent them form a magnetic epoch whence all future changes may be estimated.

The three magnetic elements, the total force, inclination or dip, and the declination, are subject to annual variations depending upon a variety of causes, at present involved in some obscurity, which sometimes appear to unite and produce violent disturbances, more or less irregular in all their magnetic elements, and known as magnetic storms. These simultaneous disturbances are closely watched in different parts of the world, and the observations, of which there are now some millions, show that they are frequently simultaneous over a large portion of the earth's surface. A notable magnetic storm was simultaneously perceptible at Toronto, the Cape Prague, and Hobarton. Another was simultaneously felt in Sicily and at Upsala, while at Altona it was unperceived. These periodical disturbances are so regular in their simultaneity that it has been suggested that they may be used for determining the difference of longitude between two stations. These disturbances, which were long believed to be casual and irregular, General Sabine has found to be apparently governed by the sun's place in the heavens; numerous observations proving that although they may vary locally, both in direction and intensity, the hourly and annual variations at one spot appear to differ in the same ratio as those taken elsewhere. These diurnal and annual variations may be dependent either on the varying heat or place of the sun, or both, for it is found that the three magnetic elements deviate from their mean annual state, so as to have maximum values in September and April, and minimum in January and June, the aggregate of the maximum values being three times greater than that of the minimum.

On account of the rotation of the earth, the diurnal disturbances, the total force, and consequently the inclination also, deviate from their mean value, and have two maximum values and two minimum in the course of 24 hours, and the declination makes two deviations to the E. and two to the W. from its mean position in the same period. The great disturbances are found to be independent of the metereological variations going on at the same time.

Throughout the middle latitudes of the northern hemisphere the N. end of the magnet has a mean motion from E. to W. from eight in the morning till half-past one; it then moves to the E. till evening, after which it makes another excursion to the W., and returns again to its original position at eight in the morning. The extent of its variation is greater in the day than in the night, in summer than in winter. It decreases from the middle latitudes in Europe, where it is 13 or 14 minutes, to the equator, where it is only three or four; but at the equator the variations are performed with extreme regularity. The horary motions of the S. end of the magnet in the southern hemisphere are accomplished in an exactly opposite direction. Between the two magnetic hemispheres there is a zone passing through an infinity of places, and very nearly coinciding with the line of minimum magnetic intensity, where the horary phenomena of both hemispheres are combined, each predominating alternately at opposite seasons. At St. Helena, which is one of the places in question and nearly on the line of minimum intensity, the horary motion of the N. end of the magnet corresponds in direction during one half of the year with the movement in the northern hemisphere, and in the other half of the year the direction at the same hours corresponds with that in the southern hemisphere; the passage from the one to the other being at the equinoxes, when the diurnal variations at the usual hours partake more or less of the characteristics of both on different days.[1] This variation is owing to the sun's declination, its maxima happening when the sun is in or near the opposite solstices, and disappearing at or near the epochs of the equinoxes.

It had been found that the diurnal variation of each of these magnetic elements was a double progression, having each two maximum and two minimum values in their respective periods. From an attentive observation of the results obtained at the British colonial observatories, General Sabine was led to the belief that the double progression was the effect of two combined or superposed variations which have different hours of maxima and minima, and are occasioned by distinct causes; one being the regular diurnal variation caused by the difference in the sun's position relatively to the place of observation at the different hours of the day and night, and the other being the mean effect of the occasional or casual disturbances. The separation of these two variations, in order to ascertain the distinct laws of the regular solar-diurnal and the casual variations, General Sabine accomplished by the reduction and comparison, according to a method devised by himself, of more than 100,000 observations, and has thereby established the strict periodical character of the magnetic storms and their influence in producing the double maximum and minimum of the diurnal variation. In addition to the annual and diurnal periods which this examination proved to belong to the casual disturbances, it showed also that their frequency and amount in different years gradually and steadily increased from a minimum in the year 1843 to a maximum in 1848, so as to be more than twice as great at the end of that time as at the beginning of it. Thus a variation, having its period nearly 11 years, was clearly established in the casual disturbances of each of the three magnetic elements, and concurrently with this a variation having a similar period and similar epochs of maxima and minima was shown to exist in the solar-diurnal variations of each of the three elements.

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[1] At St. Helena the north end of the needle reaches its eastern extreme in May, June, July, and August, and nearly at the same hours it reaches its western extreme in November, December, January, and February. The passage from one to the other takes place at, or soon after, the equinoxes, in March and April, September and October.—Sabine's Notes to 'Cosmos,' vol. ii.

This variation is a most important discovery in itself, but becomes much more so from its connexion with the spots on the surface of the sun, first pointed out by General Sabine, which has changed the received opinion as to the cause of the variations in terrestrial magnetism. M. Schwabe, of Dessau, had observed with care the solar spots during a period of 24 years, and found that they are periodical both in frequency and number, having a regular maximum and minimum every five years, the minima being in the years 1833 and 1843, and the maxima in 1838 and 1848; thus exactly coinciding with the period of the decennial variation in the magnetic elements.[1]

There is but little doubt that magnetic storms are induced, or at any rate intensified, by changes in the sun's atmosphere. M. Schwabe's observations have received striking confirmations from various observers. In 1861 Mr. Carrington was attentively watching a large sun spot, a minute point of which suddenly burst out into a brilliant blaze of light; on making enquiries at Kew it was found that a severe magnetic storm took place exactly at the same moment.

A series of observations made on the declination, by Captain Maguire, R.N., at Point Barrow, on the shores of the Polar Sea, prove beyond a doubt that the casual disturbances there are subject to the laws of the solar hours and of the solar spots. There is also a double progression, the principal maximum being at eight in the morning both at Point Barrow and Toronto, and a secondary maximum a little before midnight. When the great disturbances were separated, the solar-diurnal variations appeared to be the same with those at Toronto and throughout the extratropical part of the northern hemisphere, the epochs of the extreme easterly and westerly variations being the same at both stations. But, notwithstanding these coincidences, there is a complete antagonism in the disturbance variations at Point Barrow and Toronto, the epochs of the deflections of the needle being nearly opposite to one another at the two stations, so that at nearly the very same hour the disturbance was easterly at the one station and westerly at the other, and *vice versâ*. At the same time a strong analogy was observed to exist between the eastern disturbance deflections at Toronto and the western at Point Barrow, and between the western disturbance deflections at Toronto and the eastern at Point Barrow.

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[1] In consequence of the action of the planets Venus and Jupiter on the sun's equator, the period of the spots is increased to $11\frac{1}{9}$ years.

The deflection caused by the occasional disturbances at Point Barrow is very much greater, when compared with the same at Toronto, than can be explained by the difference of the horizontal force of the earth at the two stations. The mean daily effect of the casual disturbances was found to be more than ten times greater at Point Barrow than at Toronto; hence, as it may be greater, equal to, or less than the diurnal solar variation, according to the latitude, it may occasion a great variety of phenomena in different localities. Besides, the aurora was seen contemporaneously with the observations 1077 times in six months, which strikingly accords with the excessive amount of the occasional disturbances at Point Barrow, as it is well known to affect the magnetic needles; but as there were great disturbances when there was no aurora, it cannot be admitted to be the sole cause of the unusually great disturbances at Point Barrow.

Every series of observations shows the universal prevalence of the period in question in the solar magnetic variations. It is a discovery of the highest importance, as it proves that the solar influence on terrestrial magnetism is cosmic, and not thermic, as has been generally believed; and this is confirmed by the action of the moon, which has little heat. M. Kreil, of Milan, first discovered the existence of a lunar diurnal variation in the declination, but, since that, the numerical values of the diurnal lunar variations in all the three magnetic elements have been determined at all our colonial observatories, and it was found that these variations presented the same general characters at the three stations. They are not affected by the decennial variation which is found in all the solar inequalities, but yet they follow a double progression, having in each element two maxima and two minima in 24 hours, which constitutes a marked difference between the action of the sun and the moon on terrestrial magnetism.[1]

The discovery of the magnetism of the atmosphere and the effects of the astounding display on the 29th August and 2nd September,

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[1] M. Lamont, of Munich, has discovered that an electric current is propagated through the surface of the earth parallel to the equator, which is intimately connected with the magnetic variations.

1859, place the aurora unquestionably in the class of electro-magnetic phenomena. The aurora occurs in the N. and S., where the air is highly condensed by cold, and consequently highly magnetic. It generally appears soon after sunset in the form of a luminous arch stretching more or less from E. to W., the most elevated point being frequently in the magnetic meridian of the place of the observer: across the arch the coruscations are rapid, vivid, and of various colours, darting like lightning to the zenith, and at the same time flitting laterally with incessant velocity. The brightness of the rays varies in an instant: they sometimes surpass the splendour of stars of the first magnitude, and often exhibit colours of admirable transparency, blood red at the base, emerald-green in the middle, and clear yellow towards their extremity. Sometimes one, and sometimes a quick succession of luminous currents run from one end of the arch or bow to the other, so that the rays rapidly increase in brightness: but it is impossible to say whether the coruscations themselves are actually affected by a horizontal motion of translation, or whether the more vivid light is conveyed from ray to ray. The rays occasionally dart far past the zenith, vanish, suddenly reappear, and, being joined by others from the arch, form a magnificent corona or immense dome of light. The segment of the sky below the arch, which rises ordinarily to the height of from five to 10 degrees, is quite black, as if formed by dense clouds. Yet this dark segment is not a cloud, for the stars are seen through it as through a dense smoke. M. Struve says "the stratus that rests on the northern horizon, and appears to be the base of all the auroræ boreales that I have seen for a long time at Dorpat (lat. 58° 21′ N.), is not a cloud, but merely the sky somewhat darkened. Very frequently, when it was quite black, and very high above the horizon, we have seen the stars without any diminution in their brilliancy. Its dark appearance is the effect of contrast with the luminous arc." This appearance seems to be the result of the presence in the air of condensed vapour in the form of minute spiculæ of ice or flakes of snow. When the aurora covers the whole heavens, the entire atmosphere is filled with the haze caused in this manner, and a dark segment may be observed resting on the southern horizon. (Loomis.) The lower edge of the arch is evenly defined; its upper margin is fringed by the streamers which converge by the effect of perspective to the magnetic poles. The apparent convergence of the arch is owing to the same cause.

On the night of the 28th-29th of August, 1859, the most brilliant aurora was seen all over Great Britain, at Brussels, Basel, Rome, and must have been visible in Africa and part of Asia. It was seen over more than the 140° of longitude, from California to Eastern Europe, and from Jamaica to an unknown distance in British

America in the N. Intermitting currents of electricity were observed in all the telegraphic wires at Brussels, and the submarine cable from Ostend to Dover remained charged with electricity all the morning of the 29th.

On the 1st and 2nd of September following there was a remarkable coincidence of a simultaneous display of northern and southern aurora. It was seen at Santiago in Chile, at the Havanna, and almost all over the northern hemisphere. It was seen at the Sandwich Islands, and throughout the whole of North America and Europe, and magnetic disturbances indicated its presence throughout all Northern Asia. An aurora was at the same time seen in South America and New Holland. On the 2nd September, at seven in the morning, the telegraphic communications all over France were greatly affected, and, on interrupting the circuit of the conducting wire at Paris, strong sparks were given out. Similar disturbances were observed in the telegraphic communications in Switzerland; and the aurora on the night of the 2nd was so bright, and its effects so great, in the United States, that the operators were enabled to work the telegraph between Boston and Portland for two hours without batteries. These remarkable disturbances due to the aurora were currents in the earth from N. to S.; they had that direction at Rome and Leghorn, according to the observations of Padre Secchi and Mr. Maure, as well as in Paris. All showed an increase in the intensity of the vertical component force and a diminution in the horizontal one, with an augmentation in the inclination and declination.

The terrestrial currents, that only appear during the aurora in a decided manner, no doubt always exist permanently and imperceptibly, chiefly in the northern regions, for the discharge between the positive electricity of the atmosphere and the negative electricity of the earth must constantly take place near the pole, with an intensity varying with the season and atmosphere.

The direction of the terrestrial currents ought by theory to be that of the terrestrial meridian, but in the far N. the influence of the terrestrial magnetism makes a deviation in the currents in the atmosphere, which, being perfectly movable, easily obey the action of a foreign force; and that is the reason why the centre of the aurora is in the magnetic pole, and not in the terrestrial. "Auroras are almost unknown within the tropics. They occur with the greatest frequency in a zone of an oval form which surrounds the N. pole, and whose central line crosses the meridian of Washington in latitude 56°, and the meridian of St. Petersburgh in latitude 71°. Accordingly auroras are much more frequent in the United States than they are in the same latitudes of Europe. The form of this auroral zone bears considerable resemblance to a magnetic parallel, or line everywhere perpendicular to a magnetic meridian." (Loomis's 'Meteorology.')

In Greenland the auroral arch lies to the N. of the observer, and Sir Edward Parry saw it to the S. in Melville Island; consequently it appears in the zenith in some places. From a multitude of observations, it is concluded that the aurora seldom appears at an elevation less than about 45 miles above the earth's surface, and that it frequently extends upward to an elevation of 500 miles. The aurora of August 18, 1859, pervaded more or less the entire interval between the elevations of 46 and 500 miles above the earth's surface. Auroral arcs having a well-defined border are generally less than 100 miles in height.

Observations have proved that the disturbances of the magnetic needle and the auroral displays were simultaneous at Toronto, in Canada, on 13 days out of 24, the remaining days having been clouded; and contemporaneous observations show that on these 13 days there were also magnetic disturbances at Prague and at Tasmania, so that the "occurrence of aurora at Toronto on these occasions may be viewed as a local manifestation connected with magnetic effects, which probably prevailed on the same day over the whole surface of the globe."[1] At Point Barrow, on the shores of the Polar Sea, Captain Maguire, R.N., mentions, that during the months of December, January, and February, a time at which there was hardly any daylight, the aurora appeared six days out of every seven for two years, and that it was seen contemporaneously 1077 times with considerable magnetic disturbances; but similar disturbances often occurred without it. It has been observed that the two kinds of auroral action bear a strong analogy to the two modes of magnetic action discovered by Dr. Faraday, the ordinary auroral beams or streamers being parallel to the magnetic meridian, and the auroral arch at right angles to it. Padre Secchi has shown that the aurora is decidedly an electrical phenomenon, that its line coincides very nearly with the isothermal line of zero, and that it must always appear when the atmosphere is full of small needles of ice, conditions which explain the singular action upon the magnetic needle of certain cirrus clouds formed of minute icicles. The auroras of 1859 produced exactly the same effects as currents of electricity. The auroral light is electric light, and its colours are the same as those of ordinary electricity passing through rarefied air. The auroral beams are illumined spaces caused by the flow of electricity through the upper regions of the atmosphere, and are probably the result of currents of electricity travelling in the direction of the axis of the beams. The flashes of light are due to inequalities in the motion of the electric currents through the imperfectly conducting medium, the air.

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[1] General Sabine's Notes to the English translation of Humboldt's '*Cosmos*,' vol. ii.

Auroras, like the solar spots, and the mean daily range of the magnetic needle, exhibit two distinct periods of greatest frequency; one a period of from 10 to 12 years, the other a period of from 58 to 60 years.

There appears to be an increased quantity of ozone in the atmosphere during the auroral apparitions; it was observed to be particularly great on the 29th August and 2nd September, 1859, at Paris.

CHAPTER XXV.

VEGETATION.

§ 1. Range of vegetation on the earth's surface; nourishment and growth of plants; ripening of fruits; effects of the different rays of the solar spectrum; chemical elements of plants; their perfume. § 2. Sleep of plants. § 3. Propagation of plants; their floral organs. § 4. Classification of plants; botanical districts; causes of the distribution of the vegetable kingdom; dispersion of seeds by currents, winds, birds, and man.

§ 1. IN the present state of the globe a third part only of its surface is occupied by land, and probably not more than a fourth part of that is inhabited by man; but animals and vegetables have a wider range. The greater part of the land is clothed with vegetation and inhabited by quadrupeds, the air is peopled with birds and insects, and the sea teems with living creatures and plants. These organised beings are not scattered promiscuously, but all classes of them occupy localities suited to their respective wants. Many animals and plants are indigenous only in determinate spots, while a thousand others might have supported them as well, as is proved by many of them thriving in such places when transported thither by man.

Plants extract from the ground inorganic substances which are indispensable to bring them to maturity, but the atmosphere supplies the vegetable creation with the principal part of its nourishment.

The black or brown mould which is so abundant is the produce of decayed vegetables. When the autumnal leaves, the spoil of the summer, fall to the ground, and their vitality is gone, they slowly decompose, and, combining with the oxygen of the atmosphere, an equal volume of carbonic acid gas is evolved, which is absorbed by the water that exists abundantly in every good soil, and is the most important element in the nourishment of vegetables.

In loosening and refining the soil, as well as in facilitating the burial of dead leaves, and mixing these with the soil, the common earth-worm is the fellow-labourer with man; it eats earth, and, after extracting the vegetable matter, ejects the refuse, which is the finest soil, and may be seen lying in heaps at the mouth of its burrow. So instrumental is this creature in preparing the ground, that it is said there is not a particle of the finer vegetable mould that has not passed through the intestines of a worm: thus the most feeble of living things is employed by Providence to assist man.

The food of the vegetable creation consists of carbon, oxygen, hydrogen, and nitrogen; plants obtain the two former entirely from the atmosphere, the two latter chiefly from the earth, in the form of water and ammonia. After having imbibed and decomposed these substances, they give back the oxygen to the air, and consolidate the carbon, water, and nitrogen into wood, leaves, flowers, and fruit.

The vitality of plants is a chemical process entirely dependent on the sun's light; it is most active in clear sunshine, feeble in the shade, and nearly suspended during the night, when plants, like animals, have their rest.

The atmosphere contains about one three-thousandth part of carbonic acid gas; yet that small quantity yields enough of carbon to form the solid mass of all the magnificent forests and plants that clothe the face of the earth, and the supply of that necessary ingredient in the composition of the atmosphere is maintained by the breathing of animals, by fermentation, by volcanoes, by decomposition of animal and vegetable matter, and by combustion. The green parts of plants constantly imbibe carbonic acid in the day: they decompose it, assimilate the carbon, and return the oxygen pure to the atmosphere.

Since the vivifying action of the sun brings about all these changes, a superabundance of oxygen is exhaled by the tropical vegetation under a clear unclouded sky, where the sun's rays are most energetic, and atmospheric moisture most abundant. In the middle and higher latitudes, on the contrary, the supply of oxygen is greatly less. But an equilibrium is established by means of the winds; the tropical currents carrying the excess of oxygen to higher latitudes, to give breath and heat to men and animals. Harmony exists between the animal and vegetable creations; animals consume the oxygen of the atmosphere, which is restored by the exhalation of plants, while plants consume the carbonic acid exhaled by men and animals; the existence of each is thus due to their reciprocal dependence. Few of the great cosmical phenomena have only one end to fulfil: they are the ministers of the manifold designs of Providence.

When a seed is thrown into the ground, the vital principle of the contained embryo is stimulated by heat and moisture; its radicle (which is a definite point of the embryo destined for the purpose) elongates and gives off roots, while the plumule ascends and forms the stem and rudimentary leaves. These roots suck up water mixed with carbonic acid from the soil, to be decomposed by the plant which consolidates the carbon. In this stage of their growth, plants derive their whole sustenance from the ground. As soon, however, as the perfect leaves are formed, they absorb and decompose the carbonic acid of the atmosphere, retain the carbon for their food, and give out the oxygen in the day. It appears wonderful that so small a quantity of carbonic acid as exists in the air should suffice to supply the whole vegetation of the world, until we reflect that the total amount in the air is infinitely greater than all that which is fixed in our forests and coal-fields; and that a process of decomposition replaces the waste. Still more wonderful does it appear that a seed minute enough to be wafted invisibly by a breath of air should be the theatre of all the chemical changes that make it germinate.[1]

The fluid matter in the soil, containing different substances in solution, is absorbed by the extremities of the roots (in the case of exogenous plants), ascends to the stem, passes through the woody tissue, forms vessels and cells, dissolving and appropriating various new substances. Proceeding upwards and outwards, this sap reaches the bark and the leaves, where it is exposed to the air and is elaborated by the function of respiration. It then returns, or descends chiefly through the bark, either directly or in a circuitous manner, communicating with the central parts by the medullary rays, depositing various secretions, more especially in the bark, and giving origin to substances which are destined to nourish and form new tissues.[2] The course of the fluids in endogens and acrogens is not so well determined. Wood, sugar, starch, gum, oils, resins, and acids are formed through the chemical combination of the constituents of the liquid food of plants with the carbon derived from the carbonic acid of the air. It must be observed, however, that these different substances are produced at different stages in the growth of the plant; for example, starch is formed in the roots, stalk, and seed, but it is converted into sugar as the fruit ripens, and the more starch the sweeter the fruit becomes. Most of these new compounds are formed between the flowering of the plant and the ripening of the fruit, and indeed they furnish the materials for the flowers, fruit, and seed.

Ammonia, the third constituent of plants, a product of the decay and putrefaction of animal matter, also enters them by their roots with rain-water, and is resolved within them into its constituent elements, hydrogen and nitrogen. The hydrogen aids in forming the wood, acids, and other substances before mentioned; while the nitrogen enters into every part of the plant and forms new compounds; it exists in the blossom, in the fruit before it is ripe, and in the wood, as albumen; it also exists in gluten, which is the albuminoid part of wheat, barley, oats, and all other cerealia, as well as of esculent roots and tubers, &c. Nitrogen exists abundantly in peas, beans, and pulse of every kind,[1] and it enters into the composition of most alimentary vegetable substances; the use of animal manure is to supply plants with this essential article of their food.

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[1] The sporules or seeds of fungi are so minute that M. Fries estimated above 10,000,000 in a single plant of the Reticularia maxima: they were so subtle that they were like smoke.

[2] Balfour's 'Manual of Botany.'

The difference of a clear or cloudy sky has an immense effect on vegetation; the ripening of fruit depends upon the serenity of the sky more than on summer temperature alone. The chemical rays of the solar spectrum have most effect not only on the germination of seed, but also on the growing plant. They penetrate the ground, and have a much greater influence on the germination of seeds than ordinary light or darkness. These rays, together with light, are essential to the formation of the colouring matter of leaves; they are most active in spring, when they are in very considerable excess as compared with the quantity of light and heat; but as summer advances the reverse takes place; those hot rays, corresponding to the extreme red of the spectrum, which faciliate the flowering and forming of the fruit, become by far the most abundant; and a set of invisible rays, which exist near the point of maximum heat in the solar spectrum, are also most abundant in summer. Mr. Hunt found that the hot rays immediately beyond the visible red destroy the colour of certain leaves; and for that reason the glass of the great palm-house at Kew Gardens is tinged pale yellow green, to exclude the scorching rays in question, though it is permeable by the other rays of heat, those of light and the chemical rays.[2]

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[1] It is very doubtful, from some late researches noticed elsewhere, that the air contains any appreciable quantity of ammoniacal gas. See M. Ville's researches in the 'Comptes Rendus.'

[2] The solar spectrum, or coloured image of the sun, formed by passing a sunbeam through a prism, is composed of a variety of invisible as well as visible rays. The chemical rays are most abundant beyond the violet end of the spectrum, and decrease through the violet, blue, and green, to the yellow, where they cease. The rays of heat are in excess a little beyond the red end, and gradually decrease towards the violet end. Besides these, there are two insulated spots at a considerable distance from the red, where the heat is a maximum. Were the rays of heat visible, they would exhibit differences as distinct as the coloured rays, so varied are their properties according to their position in the spectrum. There are also peculiar rays

In spring and summer the oxygen taken in by the plants aids in the formation of oils, acids, and the other parts that contain it; but as soon as autumn comes, the vitality or chemical action of vegetables is weakened, and the oxygen becomes a minister of destruction; it changes the colour of the leaves, and consumes them when they fall. Nitrogen, so essential during the life of plants, also returns to the atmosphere in ammonia when they die.

Although the food which constitutes the mass of plants is derived principally from water and the gases of the atmosphere, solid substances are also requisite for their growth and perfection, and these they obtain from the earth by their roots. The inorganic matters are the alkalis, phosphates, silicates, sulphates, and others.

It has already been mentioned that vegetable acids are found in the juices of all the families of plants. They are generally in combination with one or other of the alkaline substances, as potash, soda, lime, and magnesia, which are as essential to the existence of plants as the carbonic acid by which the vegetable acids are formed. None of the corn tribe can produce perfect seeds unless they have both potash and phosphate of magnesia; nor can they or any of the grasses thrive without silica, which gives the stiffness to straw, to the beard of wheat and barley, to canes, and bamboos; it is even found in solid lumps in the joints of bamboo, and is known in India by the name of tabashir. To bring the cerealia to perfection, it is indispensable that in their growth they should be supplied with carbonic acid for the plant, silica to give it strength and firmness, and nitrogen for the grain.

Phosphoric acid, combined with an earth or alkali, is found in the ashes of many vegetables, and is essential to them. Pulses contain but little of it, and on that account are less nutritious than the Cerealia. The family of the Cruciferæ, as cabbages, turnips, mustard, &c., contain sulphur in addition to the substances common to the growth of all plants; each particular tribe has its own peculiarities, and requires a combination suited to it.

The perfume of flowers and leaves is owing to a substance of the nature either of volatile oil or wax, and is often carried by the air to a great distance; in hot climates it is most powerful in the morning and evening. The odour of plants has been perceived many miles from the coasts of various hot and especially dry countries. The variety of perfumes is infinite, and shows the innumerable combinations of which a few simple substances are capable, and the extreme minuteness of the particles of matter.

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which produce phosphorescence, others whose properties are not quite made out, and probably many undiscovered influences; for time has not *yet* fully revealed the sublimity of that creation, when God said, "Let *there be* light—and there was light."

§ 2. In northern and mean latitudes winter is a time of rest to the greater part of the vegetable world, and in certain tropical climates the vigour of vegetation is suspended during the dry, hot season, to be resumed at the return of the periodical rains. The periodical phenomena of the appearance of the first leaves, the flowering, the ripening of the fruit, and the fall of the leaf, depend upon the annual and diurnal changes of temperature and moisture, and succeed each other with so much harmony and regularity, that were there a sufficient number of observations, lines might be drawn on a globe approximately indicating places where the leaves of certain plants appear simultaneously, and illustrating the other principal phases of vegetation. In places where the same plants flower on the same day, the fruit may ripen at the same period; it would therefore be interesting to know what relation lines passing through those places would have to one another and to the isothermal lines; more especially with regard to the plants indispensable to man, since the periodicity of vegetation affects his whole social condition.

Certain plants sleep during the night; some show it in their leaves, others in their blossom. Some mimosas not only close their leaves at night, but their leaf-stalks droop; in a clover-field not a leaf opens until after sunrise. The common daisy is a familiar instance of a sleeping inflorescence; it shuts up its ray-flowers in the evening, and opens its white and crimson-tipped star, the "day's eye," to meet the early beams of the morning sun; when also "winking mary-buds begin to ope their golden eyes."

The crocus, tulip, convolvulus, and many others, close their blossoms at different hours towards evening, some to open them again, others never. The ivy-leaved lettuce opens at eight in the morning, and closes for ever at four in the afternoon. Some plants seem to be wide awake all night, and to give out their perfume then only, or at nightfall. Many of the jessamines are most fragrant during the twilight: the Olea fragrans, the Daphne odora, and the night-stock reserve their sweetness for the midnight hour, and the night-flowering Cereus turns night into day. It begins to expand its magnificent sweet-scented blossom in the twilight, it is full blown at midnight, and closes, never to open again, with the dawn of day;—these are "the bats and owls of the vegetable kingdom."[1]

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[1] Dandelion opens at five or six in the morning, and shuts at nine in the evening; the goat's-beard wakes at three in the morning, and shuts at five or six in the afternoon. The orange-coloured Eschscholtzia is so sensitive that it closes during the passage of a cloud. "The marigold that goes to bed wi' the sun, and with him rises weeping," with many more, are instances of the sleep of plants: the gentianella, veronica, and other plants close their blossoms on the approach of rain.

Many plants brought from warm to temperate climates have become habituated to their new situation, and flourish as if they were natives of the soil; such as have been accustomed to flower and rest at particular seasons change their habits, and adapt themselves to the seasons of the country that has adopted them.

§ 3. Plants are propagated by seeds, offsets, cuttings, and buds; hence they, but more especially trees, have myriads of seats of life, a congeries of vital systems acting in concert, but independently of each other, every one of which might become a new plant.

All the floral organs of plants are composed of modified or transformed leaves; a law developed and established by Linnæus, and which has been since popularised by the illustrious poet Göthe. According to this law, embryo leaves have been found passing into common leaves, these into bracts, bracts into sepals, sepals into petals, these into stamens, and lastly stamens into pistils which contain the ovules. These changes are not indeed all traceable on any one plant, though several of the series may be (as from sepals to petals and stamens in the white water-lily); but all double flowers, and other so-called monsters, afford examples of it; in many of which a sudden change of one of the series into ordinary leaves is common. The double rose is easily seen to be a single rose with the stamens turned into petals; and the sepals to be modified stem-leaves.

§ 4. Plants are naturally distributed in two great sub-kingdoms—the *flowering plants*, whose flowers, containing stamens and pistils, are all formed of whorls of modified leaves, and whose young seeds, called ovules, are fertilized by the pollen of the stamens; and *flowerless plants*, as ferns, mosses, lichens, seaweeds, and fungi, whose extremely minute seeds are of a very different nature, and which have no flowers properly so called. The flowering plants are divided into two principal classes, called monocotyledons and dicotyledons; of these the monocotyledons grow from within, the foot-stalks of the old leaves always forming the outside of the stem; their leaves have parallel veins; the parts of their floral whorls are usually in threes or sixes, and their embryo has but one seed-lobe or cotyledon: to this class palms, grasses, lilies, &c., belong. The dicotyledons have leaves with netted veins; stems with distinct bark; layers of wood and pith; the parts of their floral whorls are in fours or fives, and the embryo has two seed-lobes. All British trees and woody plants belong to this class, which is by far the larger of the two.

These classes are distributed in very different proportions in different zones. Between the tropics there are four dicotyledons to one monocotyledon, in the temperate zone six to one, and in the polar regions only two to one. In the temperate zones one-sixth of the flowering plants are annuals; in the torrid zone scarcely one plant in twenty is annual, and in the polar regions only one in thirty. The number of woody plants increases on approaching the equator. In North America there are 120 different species of forest-trees, whereas in the same latitudes in Europe there are only 34.

Equinoctial America has a more extensive vegetation than any other part of the world of equal area; Europe has not above half the number of indigenous species of plants; Asia, with its islands, has far more than Europe. In a memoir on the geographical distribution of plants in Armenia and Asia Minor, M. Pierre de Tchihatchef mentions that no country of its size has such an abundant and varied flora as the latter; that the plants on five mountains only, amount to double the entire number of British species. Australia, with its islands, is estimated to possess as many vegetable species as Europe; but new fertile regions are continually being discovered, and the enormous extent of unknown country teeming with vegetation, recently traversed by Dr. Livingstone, Captains Burton and Speke, and M. du Chaillu, in tropical Africa, renders any estimation of the botanical riches of that continent impossible at present.

Since the constitution of the atmosphere is very much the same everywhere, vegetation depends principally on the sun's light, moisture, and the mean annual temperature, and it is also in some degree regulated by the heat of summer in the temperate zones, and also by exposure, for such plants as require warmth are found at a higher level on the S. than on the N. side of a mountain, in the northern hemisphere. Between the tropics, wherever rain does not fall, the soil is burnt up, and is as unfruitful as that exposed to the utmost rigour of frost; but where moisture is combined with heat and light, the luxuriance of the vegetation is beyond description. The abundance and violence of the periodical rains combine with the intense light and heat to render the tropical forests and jungles almost impervious from the rankness of the vegetation. This exuberance gradually decreases with the distance from the tropics; it also diminishes progressively as the height above the level of the sea increases, so that each height has a corresponding parallel of latitude where the climates and floras are analagous; and at the regions near the line of perpetual snow the vegetation scarcely rises above the surface of the ground, and presents a counterpart to that of the polar regions. Hence, in ascending the Himalayas or Andes from the luxuriant bases of those mountains, changes take place in the vegetation analagous to what a traveller would meet with in a journey from the equator to the poles. This law of decrease, though perfectly regular over a wide extent, is perpetually interfered with by local circumstances. From various causes, as the distribution of land and water, their different powers of absorption and radiation, together with the form, composition, and clothing of the land, and the prevailing winds, it is found that the isothermal lines, or imaginary lines drawn through places on the surface of the globe which have the same mean annual temperature, do not correspond with the parallels of latitude. Thus, in North America the climate is much colder than in the corresponding European latitudes. Quebec is in the latitude of Paris, and the country is covered with deep snow four or five months in the year, and a summer has been experienced there in which not more than 60 days had been free from frost. In the southern hemisphere, beyond the 34th parallel, the summers are colder and the winters milder than in corresponding latitudes of the northern hemisphere.

Neither does the temperature of mountains always vary exactly with their height above the sea ; other causes, as prevailing winds, difference of radiation, and geological structure, concur in producing irregularities, which have a powerful effect on the vegetable world.

However, no similarity of existing circumstances can account for whole families of plants being confined to one particular country, or even to a very limited district, which, as far as we can judge, might have grown equally well on many others. Latitude, elevation, soil, and climate, are but secondary causes in the distribution of the vegetable kingdom, and are totally inadequate to explain why there are numerous distinct botanical districts, each of which has its own vegetation, whose limits are most decided when they are separated by the ocean, mountain-chains, sandy deserts, salt-plains, or inland seas. Each of these districts is the focus of families and genera, some of which are found nowhere else, and some of which are common to others.[1]

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[1] M. de Candolle and Professor Schouw have divided the earth's surface into 20 botanical regions; and Professor Martius, of Munich, into 51 provinces, namely, 5 in Europe, 11 in Africa, 13 in Asia, 3 in Australia, 4 in North and 8 in South America, besides Central America, the Antilles, the Antarctic Lands, New Zealand, Tasmania, New Guinea, and Polynesia. To these, other divisions might be added, as the Galapagos, the flora of which is so strongly defined.

Baron Humbolt gives the following concise view of the distribution of plants, as to height :—

The equatorial zone is the region of palms and bananas.
The tropical zone is the region of tree-ferns and figs.
The subtropical zone, that of myrtles and laurels.
The warm temperate zone, that of evergreen trees.
The cold temperate zone, that of European or deciduous trees.
The subarctic zone, that of pines.
The arctic zone, that of rhododendrons.
The polar zone, that of alpine plants.

As the land rose at different periods above the ocean, each part, as it emerged from the waves, was probably clothed with vegetation, and peopled with animals, suited to its position and climate. And as the conditions and climate were different at each succeeding geological epoch, so each portion of the land, as it emerged from the ocean, would be characterized by its own vegetation and animals; and thus many centres of creation would result, all differing more or less from one another, and hence alpine floras must be of older date than those in the plains. The vegetation and faunas of those lands that differed most in age and place would be most dissimilar, while the plants and animals of such as were not far removed from one another in time and place would have correlative forms or family likenesses; yet each region would form a distinct province. During these changes the older forms may have been modified to a certain extent by the succeeding conditions of the globe.

The flora of the higher parts of the Himalaya Mountains is to some extent similar to that of Europe, many species being identical. In the mountains and valleys of Tibet, where the cold is not less than in the wastes of Siberia, the vegetation of one might be mistaken for that of the other; the gooseberry, currant, rhubarb, tamarisk, willow, and poplar, growing in both. The flora near the snow-line on the lofty mountains of Europe has also a perfect family likeness to that of high northern latitudes. In like manner many plants on the higher parts of the Chilian Andes are similar to those in Tierra del Fuego, and even identical with them; nay, the Arctic flora has a certain resemblance to the Antartic, and presents even identical species.

In the many vicissitudes the surface of the globe has undergone, continents, formed at one period were, at another, broken up into islands and detached masses by inroads of the sea, and other causes. Professor E. Forbes has shown that some of the primary floras and faunas have spread widely from their original centres over large portions of those continents before the land was broken up into the form it now has, and he thus accounts for the similarity and sometimes identity of the plants and animals of regions now separated by seas—as, for example, islands, which generally partake of the vegetation and fauna of the continents adjacent to them. Taking for granted the original creation of specific centres of plants and animals, Professor E. Forbes has clearly proved that "the specific identity, to any extent, of the flora and fauna of one area, with those of another, depends on both areas forming, or having formed, part of the same specific centre, or on their having derived their animal and vegetable population by transmission, through migration, over continuous or closely contiguous land, aided, in the case of alpine floras, by transportation on floating masses of ice."

Comparatively very few of the exogenous or dicotyledonous plants are common to two or more countries far apart. There are many more instances of wide diffusion among the monocotyledonous plants, especially grasses. The aquatic monocotyledonous plants offer perhaps more striking examples of wide diffusion over the surface of the globe than any other, whilst the cellular or cryptogamous class is the most widely diffused of all.

In islands far from continents the number of plants is small, but of these a large proportion occur nowhere else. In St. Helena, of 30 flower-bearing plants, one or two only are native elsewhere, but of 60 species of cryptogamous plants Dr. Hooker found only 12 peculiar to the island.

Plants are dispersed by currents: of 600 plants from the vicinity of the River Congo on the coast of Africa, 13 are also found on the shores of Guiana and Brazil, evidently carried by the great equatorial current to countries congenial in soil and climate. The seeds of the Entada scandens, the Guilandina Bonduc, and the cashew-nut, are wafted from the West Indian islands, by the Gulf-stream, to the coasts of Scotland and Ireland, where the climate and soil do not suit them, and where therefore they do not become naturalized, though some are stated to have vegetated. Winds also waft seeds to great distances; birds and quadrupeds, and above all man, are active agents in dispersing plants. Plants introduced by man into other than their native countries frequently become quasi-indigenous; for example, the Argemone Mexicana, stated to have been introduced into India from Mexico about three centuries ago, is now abundant in a wild state in many parts of India.

CHAPTER XXVI.

VEGETATION—*continued.*

§ 1. Vegetation of the great continents. § 2. Flora of the Arctic and colder temperate regions of the great continents. § 3. Flora of Britain and of middle and southern Europe. § 4. Flora of temperate Asia.

§ 1. THE southern limit of the polar flora, on the old continent, lies mostly within the Arctic Circle, but stretches along the tops of the Scandinavian mountains, and reappears in the highlands of Scotland, Cumberland, and Ireland, on the summits of the Pyrenees, Alps, and other mountains in southern Europe, as well as on the mountains of central Asia, and on the high ridges of the Himalaya.

The great European plain extending to the Ural Mountains, as well as the lowlands of England and Ireland, were at one period covered by a sea full of floating ice and icebergs, which made the climate much colder than it now is. At the beginning of that period the Scandinavian range, the other continental mountains, and those in Britain and Ireland, were islands of no great elevation, and were then clothed with the present Arctic flora, representatives of which they still retain now that they form the tops of the mountain-chains. At that time both plants and animals were conveyed from one country to another by floating ice. It is even probable, from the relations of their fauna and flora, that Greenland, Iceland, and the very high European latitudes, are portions of a great northern land which had for the most part sunk down at the close of the glacial period, for there were many vicissitudes of level during that epoch. At all events, it may be presumed that the elevation of the Arctic regions of both continents, if not contemporaneous, was probably not far removed in time. Similarity of circumstances had extended throughout the whole Arctic regions, since there is a remarkable similarity and even identity of species of plants and animals in the high latitudes of both continents, which is continued along the tops of their mountain-chains, even in the temperate zones; and there is reason to believe that the relations between the faunas and floras of North America, Asia, and Europe, must have been established towards the close of the glacial period.

The plants of Iceland are almost wholly identical with those of Britain, yet only one in four of the British plants are known in Iceland. There are 870 species in Iceland, of which more than half are flower-bearing. This flora is scattered in groups according as the plants like a dry, marshy, volcanic, or marine soil. Many grow close to the hot-springs; some not far from the edge of the basin of the Great Geyser; and species of Confervæ flourish in a spring said to be almost hot enough to boil an egg. The Cerealia cannot be cultivated on account of the severity of the climate, but the Icelanders make bread from metur, a species of wild corn, and also from the bulbous root of Polygonum viviparum; their greatest delicacy is the Angelica Archangelica; Iceland moss, used in medicine, is an article of commerce. There are 583 species in the Faroe Islands, of which 270 are flowering plants: many thrive there that cannot bear the cold of Iceland.

ARCTIC AND COLDER TEMPERATE FLORA OF THE GREAT CONTINENTS.

§ 2. In the most northern parts of the Arctic lands the year is divided into one long intensely cold night and one bright and fervid day, which quickly brings to maturity the scanty vegetation. Within the limit of perpetual congelation the Palmella nivalis (or red snow of the Arctic voyagers), which consists of an excessively thin stratum of microscopic red or orange-coloured globules, finds nourishment in the snow itself, the first dawn of vegetable life; it is also found colouring large patches of snow on the Alps and Pyrenees.

Lichens are the first vegetables that appear at the limits of the snow-line, whether in high latitudes or mountain-tops, and they are the first vegetation that takes possession of volcanic lavas and new islands, where they prepare soil for plants of a higher order; they grow on rocks, stones, and trees, in fact on anything that affords them moisture. Many species are known; no plants are more widely diffused, and none afford a more striking instance of the power of migration possessed by species, as they are of so little direct use to man that they have not been disseminated by his agency. The same kinds prevail throughout the Arctic regions, and species common to both hemispheres are very numerous. Some lichens produce brilliant red, orange, and brown dyes; and the tripe de roche, a species of Gyrophora, is a miserable substitute for food, as our intrepid countryman Sir John Franklin and his brave companions experienced in their perilous Arctic journeys.

Mosses follow lichens on newly-formed soil, and they are found everywhere throughout the world in damp situations, but in greatest abundance in temperate and alpine climates. Upwards of 1000 species are known, of which a considerable number inhabit the Arctic regions, constituting a large portion of the vegetation.

In Asiatic Siberia, N. of the 60th parallel of latitude, the ground is perpetually frozen at a very small depth below the surface: a temperature of the air of 70° below zero of Fahrenheit is not uncommon, and in some instances the cold has been 120° below zero. Then it is fatal to animal life, especially if accompanied by wind. In some places trees grow and corn ripens even at 70° of N. lat.; but in the most northern parts, boundless swamps, varied by lakes both of salt and fresh water, cover wide portions of this desolate country, which is buried under snow nine or ten months in the year. As soon as the snow is melted by the returning sun, these extensive morasses are covered with coarse grass, sedges, and rushes, while mosses and lichens, mixed with dwarf willows, clothe the plains.

In Novaia Zemlia and other places in the far north the vegetation is so stunted that it barely covers the ground, but a much greater variety of minute plants of considerable beauty are crowded together there in a small space than in the Alpine regions of Europe, where the same genera grow. This arises from the diminutive size of the vegetation; for in the Swiss Alps the same plants frequently occupy a large space, excluding every other species. In the remote north, on the contrary, where vitality is comparatively feeble and the seeds do not ripen, 30 different species may be seen crowded together in a bright green mass, no one having strength to overcome the rest. In such frozen climates plants may be said to live between the air and the earth, for they scarcely rise above the soil, and their roots creep along the surface, having scarcely power to enter it. All the woody plants, as the Betula nana, the reticulate-leaved willow, Andromeda tetragona, with a few berry-bearing shrubs, trail along the ground, never rising more than an inch or two above it. The Salix lanata, the giant of these Arctic forests, never grows more than five inches high, while its stem, 10 or 12 feet long, lies hidden among the moss, owing shelter to its lowly neighbours.

The chief characteristic of the vegetation of the Arctic regions is the predominance of perennial and cryptogamous plants, and also the sameness of its nature; but more to the S., where night begins to alternate with day, a difference of species appears. A beautiful flora adorns these latitudes during their brief but bright and ardent summer, consisting of potentillas, gentians, chickweeds, saxifrages, sedums, ranunculi, drabas, artemisias, claytonias, and many more. Such is the power of the sun, and the consequent rapidity of vegetation, that these plants spring up, blossom, ripen their seed, and die, in a few weeks: in a lower latitude woody plants follow these, as berry-bearing shrubs, the glaucous kalmia, the trailing azalea, and rhododendrons.

A large proportion of the plants found by Wormskiold in Kamtchatka are European, intermixed with many which are purely American. Few European trees grow in Asiatic Siberia, notwithstanding the similarity of climate, and most of them disappear towards the rivers Tobol and Irtish.

In Lapland and in the high latitudes of Russia large tracts are covered with birch-trees, but the pine and fir tribe are the principal inhabitants of the N. Prodigious forests of these are spread over the mountains of Norway and Sweden, and in European Russia 200,000,000 acres are clothed with these Coniferæ alone, occasionally mixed with willows, poplars, and alders. Although tracts of pure sand and limestone are absolutely barren, yet the soil generally contains enough of alkali to supply the wants of the fir and pine tribe, which require ten times less than oaks and other deciduous trees.

Social plants abound in many parts of the northern temperate regions, as grass, heath, furze, and broom; the steppes are an example of this on a very extensive scale. Both in Europe and Asia they are subject to a rigorous winter, with deep snow and chilling blasts of wind: and as the soil generally consists of a coating of vegetable mould over clay, no plants with deep roots thrive upon them; hence the steppes are destitute of trees, and even bushes are rare except in ravines; the grass is thin, but nourishing. Hyacinths and some other bulbs, mignonette, asparagus, liquorice, and wormwood, grow in the European steppes; the two latter are peculiarly characteristic.

Each steppe in Siberia has its own association of plants; the Peplis and Camphorosma are peculiar to the steppe of the Irtish, and the Amaryllis tartarica abounds in the meadows of Eastern Siberia, whose vegetation bears a great analogy to that of North-western America, many genera and species being common to both.

The Siberian steppes are bounded on the S. by great forests of pine, birch, and willow; poplars, elms, and Tartarian maple overhang the upper courses of the noble rivers which flow from the mountains to the Frozen Ocean; and on the banks of the Yenisei the Pinus Cembra, or Siberian pine, with edible seeds, grows 120 feet high. The Altaï are covered in some parts nearly to their summits with similar forests, but on their greatest heights the stunted larch crawls on the ground, and the flora is like that of Northern Siberia: round Lake Baikal the Pinus Cembra grows nearly to the snow-line.

Forests of black birch are peculiar to Dauria, where there are also apricot and apple trees, and rhododendrons, of which a species with yellow blossoms grows in thickets on the hills. Here and everywhere else throughout Central Asia are found various species of Caragana, a genus eminently Siberian.

The elevated mountain mass of Tibet has the character of great sterility, and the climate is as unpropitious as the soil: frost begins early in September, and continues with little interruption till May; snow, indeed, in some parts, falls every month in the year, though in excessively small quantities, owing to the extreme dryness of the climate. The air is always dry, because moisture falls chiefly in winter, in the form of snow, and in summer it is quickly evaporated by the intense heat of the sun. The thermometer sometimes rises to 144° of Fahrenheit, and even in winter the direct rays of the sun have great power for an hour or two, so that a variation of 100° in the temperature of the air has occurred in 12 hours. Notwithstanding these disadvantages, there are sheltered spots, heated by radiation from the dry rocky mountain flanks, which produce most of the European grains and fruits, the vegetation being of Siberian character, and the species to a considerable extent identical. The most common indigenous plants are Tartarian furze (Caragana), and various prickly shrubs resembling it—gooseberries, currants, hyssop, dog-rose, dwarf sow-thistle, and rhubarb. Prangos, an umbelliferous plant, with abundant foliage is peculiar to Ladak and other parts of Tibet. Mr. Moorcroft says it is so nutritious, that sheep fed on it become fat in twenty days. There are three varieties of wheat, three of barley, and two of buckwheat cultivated, as also are maize and rice together with pulses, lucerne, lentils, and spinach. Olives, pears, apples, peaches, apricots, mulberries, grapes, currants, and melons of large size and delicious flavour are produced. Cotton of valuable quality abounds, and plants on which silkworms are fed. Owing to the rudeness of the climate, trees are not numerous, yet on the lower declivities of some mountains there are poplars, birch, walnut, willows, juniper, hippophae, and Gerard's pine, whose nuts are eaten. Between Khotan and Aksu, however, there exists for 12 marches a forest so dense that travellers are said to have been lost in it.

The great valley of Tartary N. of Tibet is chiefly occupied by the Great Gobi and other deserts of sand, with chains of salt lakes, and grassy steppes near the mountains; but of the flora of these regions we know nothing.

FLORA OF BRITAIN AND OF MIDDLE AND SOUTHERN EUROPE.

§ 3. The British Islands afford an excellent illustration of distinct provinces of animals and plants, and also of their migration from other centres. Professor E. Forbes has adopted five botanical districts, the plants of four of which are restricted to limited provinces, whilst those of the fifth, which comprehends the great mass of British plants, are everywhere. All of these, with a very few doubtful exceptions, had migrated into the British Islands before the latter were separated from the continent. The first flora, which is of great antiquity, includes that of the mountain districts of the W. and S.W. of Ireland, and is similar to that of the N. and W. of Spain. The second flora is that of the S. of England and the S.E. of Ireland, which is different from that in all other parts of the British Islands; it is intimately related to the vegetation of the Channel Islands and the coast of France opposite to them. The third flora appears in the S.W. of England, where the chalk plants prevail, and the flora is like that on the adjacent coast of France.

The tops of the loftiest British mountains form the fourth class, and are the focus of a separate flora, which is the same with that in the Scandinavian Alps, and is very numerous. Scotland, Wales, and a part of Ireland received this flora when they were groups of islands in the Glacial Sea, and some few individuals grow on the summits of the mountains in Cumberland. The rare Eriocaulon is found in the Hebrides, in Connemara, and in Northern America, and nowhere else. The fifth, of more recent origin than the Alpine flora, includes all the ordinary flowering plants, as the common daisy and primrose, hairy ladies'-smock, upright meadow crowfoot, and the lesser celandine, together with our common trees and shrubs; it migrated from Germany at a later epoch, but still before England was separated from the continent of Europe by the British Channel. It can be distinctly traced in its progress across the island, but the migration was not completed till after Ireland was separated from England by the Irish Channel. This is the reason why many of the ordinary English plants, mammals, and reptiles are not found in the sister island, for the migration of animals was simultaneous with that of plants, and took place between the last of the tertiary periods and the historical epoch. This flora extends also over a great part of the continent.[1]

Deciduous trees are the chief characteristic of the temperate zone of the whole continent, more especially of middle Europe. Oaks, elms, beech, ash, larch, maple, lime, alder, and sycamore, all of which lose their leaves in winter, are the prevailing trees, occasionally mixed with social pines and firs, together with grass pastures and extensive heaths in some places.

Evergreen trees and shrubs, with shining leaves, become more frequent in the southern countries of Europe, where about a fourth part of the woody plants never entirely lose their leaves. The trees and shrubs consist chiefly of evergreen oaks, cypress, hornbeam, sweet chestnut, laurel, lauristinus, walnut, maple, manna or the flowering ash, carob, jujube, juniper, pistachios (some of which yield oily nuts, some resin, and some mastic), arbutus, myrtle, jessamine (yellow and white), and various pines, as the Pinus maritima, and Pinus pinea, or stone pine, which forms so picturesque a feature in the landscape of southern Europe. The most prevalent herbaceous plants are Compositæ, Grasses, and Caryophylleæ, as pinks, Stellaria, and Arenarias; and also the labiate tribe, mint, thyme, rosemary, lavender, with many others, all remarkable for their aromatic properties and their love of dry situations. Many of the choicest plants and flowers which adorn the gardens and grounds in northern Europe are indigenous in these warmer countries: the anemone, mignonette, narcissus, gladiolus, iris, asphodel, amaryllis, carnation, &c. In Spain, Portugal, Sicily, and the other European shores of the Mediterranean, tropical families begin to appear in the Aroideæ, plants yielding balsams, oleander, date and palmetto palms, and grasses of the group of Panicum or millet, aloes and cactus. In this zone of transition there are six herbaceous for one woody plant.

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[1] The British flora contains at least 3000 species, of which about 1400 are flowering plants.

FLORA OF TEMPERATE ASIA.

§ 4. The vegetation of Western Asia approaches to that of Western India at one extremity and North Africa and Eastern Europe at the other. Syria and Asia Minor form a region of transition, like the other countries on the Mediterranean, where the plants of the temperate and tropical zones are united. We owe many of our best fruits and sweetest flowers to these regions. The cherry, almond, oleander, syringa, locust-tree, &c., come from Asia Minor; the walnut, peach, melon, cucumber, hyacinth, ranunculus, come from Persia; the date-palm, fig, olive, mulberry, and damask-rose, come from Syria; the vine and apricot are Armenian; the latter is cultivated everywhere in middle and northern Asia. The tropical forms met with in more sheltered places are the sugar-cane, date, and palmetto palms, acacias, Asclepias gigantea, and arborescent Apocyneæ. The singular gorge of the Jordan valley presents a tropical vegetation. The papyrus, now extinct in Egypt, is found in the marshes of Merom; and the Zizyphus spinachristi is characteristic of the whole course of the river. The "Zukkum," or false balm of Gilead, the osher tree of Nubia and Abyssinia, the henna or camphire, and the Salvidora persica abound. The flowers are of Abyssinian, south Arabian, and some of Indian types.[1] The Nelumbium speciosum grows in one spot five miles from the town of Astracan, and nowhere else in the wide domains of Russia; the leaves of this beautiful aquatic plant are often two feet broad, and its rose-coloured flowers are very fragrant. It is also a native of India, where it is held sacred, as it was formerly in Egypt, where it is said to be extinct: it is one of the many instances of a plant growing in countries far apart.

The plains of Persia are covered with a clayey, sandy, or saline soil, and the climate is very dry; hence vegetation is poor, and consists of thorny bushes, acacias, tamarisk, jujube, &c. Forests of oak cover the mountains of Laristan, but the date-palm is almost the only arborescent produce of the parched shores of the Arabian Gulf and of the oases on the Persian plains. In the valleys, which are beautiful, there are clumps of Oriental plane and other trees, hawthorn, tree-roses, and many of the odoriferous shrubs of Arabia Felix.

Afghanistan, which for the most part consists of a mass of sterile mountains, produces in its valleys the seedless pomegranate, acacias, date-palms, tamarisks, &c. The valleys of the Hindoo Coosh present clover, thyme, violets, and many odoriferous plants: the greater part of the trees in the mountains are of European genera.

Hot, arid deserts bound India on the west, where the stunted and scorched vegetation consists of tamarisks, thorny acacia, deformed Euphorbiæ, and almost leafless thorny trees. Indian forms begin to abound east of the Indus, but Syrian and Persian genera and species accompany these as far east as Delhi.

The Himalaya mountains form a distinct botanical district. Immediately below the snow-line the flora consists of Arctic, Siberian, Alpine, European, and Caucasian forms, amongst which rhododendrons and andromedas are conspicuous. Lower down European forms become universal, though the species are Indian. There are extensive forests of Coniferæ, consisting chiefly of Pinus excelsa, Pinus deodara, and Smithiana, with many deciduous forest and fruit trees of European genera. Here the scarlet and other rhododendrons grow luxuriantly; walnuts, numerous species of oak, many of which attain a great size, and maples. A transition from this flora to a tropical vegetation takes place between the altitudes of 4000 and 6000 feet. On the hot declivities of the mountains, tropical types, as Erythrina and Bombax heptaphyllum, are common trees, together with the Sal-tree (Shorea robusta), Dalbergia and Cedrela, a genus allied to mahogany. The flora of the Punjab is greatly modified by the circumstances of the increase of cold going northward or upwards in the hills, and also of the greater aridity towards the W. and towards the interior of the hills. Distance from the hills also increases aridity, and the most arid part of the plains of the Punjab is probably near, and to the W. of, Multán, where the unusual rainfall is reckoned by fractions of an inch. The aridity lessens the amount of the vegetation, and modifies its nature. In passing from the outer and middle ranges of the Himalaya into the semi-Tibetan tracts of the Upper Sutlej and Upper Chenáb, this is very evident; and in Ladák, where great elevation is added to intense dryness, trees are almost unknown and shrubs rare, the herbaceous plants are widely different from those growing in the outer hills. Ferns, orchids, and balsams are extremely rare in the Punjáb.[1]

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[1] Tristram's 'Natural History of the Bible.'

It is remarkable that Indian, European, American and Chinese forms are united in the above-mentioned zone of transition, though the distinctness of species still obtains: the Triosteum, a genus of the honeysuckle tribe, is American; the Abelia, another genus of the same tribe, together with Camellia and others, are peculiarly Chinese: the wild thyme is European.

The temperate regions of Eastern Asia, including Mongolia and Manchuria, Northern China, and Japan, have a vegetation totally different from that of any other part of the globe similarly situated, but closely allied to the temperate Himalayan, and show in a strong point of view the distinct character which vegetation assumes in different longitudes. In Manchuria and the vast mountain-chains that slope from the eastern extremity of the high Tartarian tableland to the fertile plains in China, the plants are generally of European genera, but Asiatic species; in these countries the buckthorn and honeysuckle tribes are so numerous as to give a peculiar character to the vegetation. Mixed with these and with roses are thickets of azaleas covered with blossoms of dazzling brightness and beauty.

The transition zone in this country lies between the 35th and 27th parallels of north latitude, in which the tropical flora is mixed with that of the northern provinces. The prevailing plants on the Chinese low grounds are Glycine, Hydrangea, the camphor laurel, Stillingia sebifera or wax-tree, Clerodendron, Hibiscus rosa-sinensis, Thuja orientalis, Olea fragrans, the sweet blossoms of which are mixed with the finer teas to give them flavour; Melia azedarach, or Indian pride, the paper mulberry, and others of the genus, and Camellia sasanqua, which covers hills in the province of Kiang-si. The tea-plant and other species of Camellia, grow in many parts; the finest tea is the produce of a low range of hills between the 33rd and 25th parallels, an offset from the great chain of Peling.[1]

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[1] Stewart's 'Punjab Plants.'

The climate of southern Japan is milder than its latitude would indicate, owing to the influence of the surrounding ocean. European forms prevail in the high lands, as they do generally throughout the mountains of Asia and the Indian Archipelago, with a difference of species. The Japanese flora is similar to the Chinese, and contains numerous American plants, besides others of Indian and tropical climates. These islands, nevertheless, have their own peculiar flora. Many tropical plants mingle with the vegetation of the Southern Islands.

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[1] Thea viridis and bohea are possibly only varieties of the same plant; the black tea is a more robust, the green a more delicate plant. The quality of the tea depends upon the stage of growth at which it is gathered; early leaves make the best tea; those picked late in the season give a very coarse tea. Bohea grows in the province of Fo-kien, hyson in Song-lo. Pekoe, or pak-ho, which means "white down" in Chinese, consists of the first downy sprouts or leaf-buds of three-years-old plants. A very costly tea of this kind, never brought to Europe, and known as the tea of the Wells of the Dragon, is used only by persons of the highest rank in China. The true Imperial tea also, called Flos theæ, which is not, as was supposed, the flower-buds, but merely a very superior quality of tea, seldom reaches Europe; that sold under this name is really Chusan tea flavoured with blossoms of Olea fragrans. The Chinese keep tea a year before they use it, because fresh tea has an intoxicating quality which produces disturbance of the nervous system. It is a remarkable circumstance that tea and coffee, belonging to different families, natives of different quarters of the globe, should possess the same principle—theine and caffeine are in most respects identical—and it is not less remarkable that their application to the same use should have been so early discovered by man. Tea was first brought to Europe by the Dutch in 1610; a small quantity came to England in 1666, and now the annual consumption of tea in Great Britain is upwards of 50,000,000 of pounds.—Davis' 'China.'

The tea-plant grows naturally in Japan and Upper Assam: it is hardy and possesses great power of adaptation to climate. It has lately been cultivated in Brazil and in Algiers, at an expense which renders it unprofitable; but it is already very remunerative in Assam and throughout the Himalaya, especially in the Kangra Valley, in the upper part of the basin of the Bias. Tea comes to Europe almost exclusively from China, but the plant thrives so well in the north-western provinces of India that the English will ultimately compete with the Chinese in producing it, especially for the Tibet market. In 1869, Mr. Shaw penetrated to Yarkand, carrying Kangra tea.

The plants with which the Chinese give flavour to tea are the Olea fragrans, Chloranthus inconspicuus, Gardenia florida, Aglaia odorata, Jasminum sambac, Vitex spicata, Camellia sasanqua and odorifera, Illicium anisatum, Magnolia yulan, Rosa indica, turmeric, oil of Bixa orellana, and the root of the Florentine iris.

CHAPTER XXVII.

VEGETATION—*continued.*

§ 1. Flora of the Indo-Chinese Peninsula, and the Indian Archipelago. § 2. Indian flora. § 3. Arabian flora.

§ 1. TROPICAL Asia is divided by nature into three distinct botanical regions: the Malayan peninsula, with the Indian Archipelago; India south of the Himalaya, with the island of Ceylon; and the Arabian peninsula. The two former have strong points of resemblance, though their floras are peculiar.

FLORA OF THE INDO-CHINESE PENINSULA AND THE INDIAN ARCHIPELAGO.

Many of the vegetable productions of the peninsula beyond the Ganges are the same with those of other parts of India, mixed with the plants of the Indian Archipelago, so that this country is a region of transition, though it has also a splendid vegetation of peculiar productions, dyes of the most vivid hues, spices, medicinal plants, and many with the sweetest perfume. The soil in many places yields three crops in the year: the fruits of India, and most of those of China, come to perfection in the low lands. Various palms adorn the Malayan peninsula: of these the Arang is eminently characteristic of that country; it is an ugly plant, whose stem is covered with black fibres like horsehair, sufficiently strong to make cordage. It is cultivated for the sugar and wine made from its juice. Teak is plentiful; almost all that is used in Bengal comes from the Birman empire, though it is less durable than that of the Malabar coast. The Hopea odorata is so large that a canoe is made of a single trunk; the Gordonia integrifolia is held in such veneration that every Birman house has a beam of it.

There are many species of native oak in the forests: the Mimosa catechu, which furnishes the terra japonica; the trees which produce varnish and stick-lac; the Glyphyria nitida, a myrtle, the leaves of which are used as tea in Bencoolen, called by the natives the tree of long life. The coasts are wooded by mangroves, casuarina, and the Heritiera robusta, a large tree which thrives within reach of the tide; bamboos with stems a foot and a half in diameter grow in dense thickets in the low lands. The Palmyra palm and the Borassus flabelliformis grow in extensive groves in the valley of the Irrawaddy: the latter is a magnificent tree, often 100 ft. high, remarkable for its gigantic leaves, one of which would shelter 12 men.

The anomalous family of the Cycadeæ, somewhat like palms with large pinnated leaves, is found here and in tropical India. Orchideæ and tree-ferns are innumerable in the woody districts of the peninsula.

The vegetation of the Indian archipelago is gorgeous beyond description; although it bears a strong affinity to that of the Malayan peninsula, tropical India, and Ceylon. The height of the mountains causes variety in the temperature sufficient to admit of the growth of dammar pines, oaks, rhododendrons, magnolias, maples, honeysuckles, vacciniums, and other European orders of woody and herbaceous plants; yet they have scarcely one species in common with Europe.

Palm-trees are more abundant in these islands than in any other part of the world, except tropical America, where the species exist in such great number and diversity. Three species of Areca, attaining a height of more than 40 or 50 feet, are cultivated in all the hot parts of India; and Caryota urens (the fruit of which is acrid, although the sap yields wine and sugar) is also a native. The attempt is vain to specify the multitudes of these graceful trees, which form so characteristic a feature in the vegetation of these tropical islands, where a rich moist soil with intense heat brings them to such perfection.

Jungle and dense woods entirely cover the smaller islands and the plains of the larger; the coasts are lined with thickets of mangroves, a matted vegetation of forest-trees, bamboos, and coarse grass, entwined with climbing and creeping plants, and overgrown by orchideous parasites in myriads: the gutta-percha is also a native of these alluvial tracts. The forest-trees of the Indian Archipelago are extremely numerous; teak and many of the continental trees grow there, but the greater number are peculiarly their own. The naturalist Rumphius had a cabinet inlaid with 400 kinds of wood, the produce of Amboyna and the Molucca Islands.

Borneo and the adjacent islands are the region of the Dryobalanops camphora, in the stems of which beautiful amber-coloured crystals of a remarkable and costly kind of camphor are found. There are thickets of the Pandanus or screw-pine, a plant resembling a gigantic pine-apple.

This is the region of spices, which are very limited in their distribution: the Myristica moschata (the nutmeg and mace-plant) is confined to the Banda Islands, but it is said to have been discovered lately in New Guinea. The Amboyna and the Molucca groups are the focus of the Caryophyllus aromaticus, a myrtle, the flower-buds of which are known as cloves. Various species of cinnamon and cassia, both of the laurel tribe, together with peppers, grow in this archipelago. All the pepper-plants require great heat; the common black pepper is peculiar to the hottest parts of Asia, extending only a few degrees on each side of the equator. Some of the most excellent fruits are indigenous here only, as the durian, the ayer-ayer, loquat, the choapa of the Moluccas, peculiar kinds of orange, lemon, and citron, with others known only by name elsewhere, especially the mangosteen, which is almost peculiar. Those common to the continent of India are the jambose or rose-apple, jack, pine-apple, mango, and the banana.

Here the nettle tribe assume the most pernicious character, as the upas-tree of Java, one of the most deadly vegetable poisons: and even the plants resembling our common nettle are so acrid that the sting of one in Java occasions not only pain but illness which lasts for days. A nettle in the island of Timor, called by the natives the 'Devil's leaf,' is so poisonous that it produces long illness and even death. The chelik, a shrub growing in the dense forests, produces a poison even more deadly than the upas. Some of the fig genus, which is allied to the natural order of nettles, have acrid juices.

Sir Stamford Raffles describes the vegetation of Java as "fearful." In some of these forests the air is heavy, charged with dank and deadly vapours, rarely agitated by a breath of wind; the soil, of the deepest black vegetable mould, always moist and clammy, stimulated by the fervid heat of a tropical sun, produces trees whose stems are of a spongy texture from their rapid growth, and loaded with parasites, particularly the orchidaceous tribes. Tree-ferns form a large portion of the vegetation of Java and all these islands.

The Rafflesias, of which there are four species, are the most singular productions of this archipelago. The most extraordinary one was discovered in Sumatra by Dr. Arnold, and is therefore called Rafflesia Arnoldi. It is a parasitical plant, consisting of nothing but a flower, which vegetates in the prostrate stems of a gigantic vine. Its buds are the size of an ordinary cabbage, and the flower, which smells of carrion, is of a brick-red colour, three-and-a-half feet in diameter. It weighs 15 pounds, and the cup in its centre could contain 12 pints of liquid.

According to Sir Stamford Raffles there are six distinct climates in Java, from the top of the mountains to the sea, each having an extensive indigenous vegetation. No other country can show an equal abundance and variety of native fruit and esculent vegetables. There are 100 varieties of rice; and of fragrant flowers, shrubs, and ornamental trees the number is infinite. Abundant as the Orchidaceæ are in Java, Ceylon, and the Burmese empire, these countries possess very few that are common to them all, so local is their distribution. Ferns are more plentiful in this archipelago than elsewhere; tree-ferns are found chiefly between or near the tropics, in damp places.

INDIAN FLORA.

§ 2. The plains of Hindostan are so completely sheltered from the Siberian blasts by the high mountain ranges of Tartary and the Himalaya, and heated and watered by the monsoons, that the vegetation at the foot of that range already assumes a tropical character. In the jungles and lower ridges of the fertile valleys of the central and eastern Himalaya, and in the dark recesses of the Silhet and Malabar forests, arborescent ferns and orchidaceous plants are found in a profusion scarcely surpassed even in the islands of the Indian archipelago. The Khasya mountains. S. of Assam, at the eastern extremity of Bengal, present one of the most varied and luxuriant vegetations on the globe.

The native fruits of India are many: the orange tribe is almost exclusively of Indian origin, though some of the species are now widely spread over the warmer parts of the four continents. The vine grows wild in the forests; plantain, banana, mango, date, areca, palmyra, and coco-nut palms are all Indian. The Scitamineæ, or ginger tribe, are so numerous that they form a distinguishing and beautiful feature of Indian botany; they produce ginger, cardamoms, and turmeric. The flowers peculiar to India are brilliant in colour.

Trees of the fig tribe are among the most remarkable vegetable productions of India for gigantic size and peculiarity of form, and they are most valuable in a hot climate from the shade which their broad-spreading tops afford. Some throw off shoots from their branches, which take root on reaching the ground, and, after increasing in girth with wonderful rapidity, become themselves independent trunks; and this process is continued till a forest is formed round the parent tree. Mr. Reinwardt saw in the island of Simao a large wood of the Ficus Benjamini which sprang from one stem. The Ficus Indicus, or banyan-tree, is another instance of this wide-spreading growth; there is a tree of it on the banks of the Nerbudda, in the province of Guzerat, with 350 main stems, occupying an area of 2000 feet in circumference, independent of its branches, which extend much farther. The banana is a generally useful tree in India; its fruit is food, its leaves are applied to many domestic purposes, and flax fit for making muslin is obtained from its stem. Cotton is a hairy covering of the seeds of several species of the mallow tribe which grow spontaneously in tropical Asia, Africa, and America; it is, however, cultivated in many countries beyond these limits. That grown in China and the States of North America is an herbaceous annual from 18 inches to two feet high; there are also cotton-trees, native and cultivated, in India, China, Africa, and America. Herodotus mentions cotton garments 445 years before the Christian era, and the Mexicans and Peruvians manufactured cotton cloth before the discovery of America.

Palms, the most stately and graceful of the vegetable productions of tropical regions, are abundant in India, in forests, in groups, and in single trees. The stems of some are of gigantic size, and all are beautiful, varying in length from the slender Calamus, 130 feet long, to the Phœnix acaulis, not more than three feet high. Different species yield wine, oil, wax, flour, sugar, thread, and rope; weapons and utensils are made of their stems and leaves; they serve for the construction of houses; the coco-nut palm gives food and drink.

Though palms in general are very limited in their distribution, a few species are very widely spread; for example, the coco-nut palm is found in all the tropical regions of the globe, where it has been extensively cultivated from its usefulness. Their growth in Ceylon is extremely luxuriant. In parts of that island, on the Malabar and Coromandel coasts, and in some districts of Bengal, the Borassus flabelliformis supplies its place.

The island of Ceylon, which may be regarded as the southernmost extremity of the Indian peninsula, is very mountainous, and in luxuriance of vegetable productions rivals the islands of the Indian archipelago, with the vegetation of which its own has the strongest affinity. The species of laurel, the bark of which is cinnamon, is indigenous, and is one of the principal sources of the revenue of Ceylon. The leaves of a species of palm, the talipot, are of enormous size, and are applied to many uses by the Cingalese: in ancient times strips of the leaf were written upon with a sharp style, and served as books. The sandal-wood of Ceylon is of a different species from that of the South Sea islands, and its perfume more esteemed. The mountains produce a great variety of beautiful woods used in cabinet work.

ARABIAN VEGETATION.

§ 3. The third division of the tropical flora of Asia is the Arabian, which differs widely from the other two, and is chiefly marked by shrubs yielding balsams. Oceans of barren sand extend to the S., from Syria through the greater part of Arabia, varied only by occasional oases in those spots where a spring of water has reached the surface; there the prevalent vegetation consists of grasses, growing under the shade of date-palms; acacias and stunted prickly bushes appear here and there in the sand. There is verdure on the mountains, and along some of the coasts, especially in the province of Yemen, which has a flora of its own. Eight species of figs, three species of amyris or balm of Gilead, opobalsamum also yielding balsam, and the kataf, from which myrrh is supposed to come, are found in Arabia. Frankincense is said to be the produce of the Boswellia serrata; and there are many species of Acacia, among others the Acacia arabica, which produces gum arabic. The chief characteristics of the Arabian flora, as distinguishing it from the Indian and Persian, are many species and genera of Abyssinian plants, among which are found stapelias and other representatives of the Cape of Good Hope flora.

Arabia produces coffee, which, however, is not indigenous, but is supposed to have come from the mountains of Abyssinia, and to have its name from the province of Kaffa, where it is said to form dense thickets. It was introduced into Arabia at the end of the 15th century, and grows luxuriantly in Arabia Felix, where the coffee is of the highest flavour. Most of that now used is the progeny of plants raised from seed brought from Mocha to the Botanic Garden at Amsterdam in 1960, by Van Hoorn, Governor of Batavia. A plant was sent to Louis XIV., in 1714, by the magistrates of Amsterdam—it was from this plant that the first coffee-plants were introduced in 1717 into the West India islands. A year afterwards the Dutch introduced coffee-trees into Surinam, whence they spread rapidly over the warm parts of America and the West India islands. Many thousands of people are now employed in its cultivation there, in Demerara, Java, Manilla, the isle of Bourbon, and other places. Coffee was not known till many centuries after the introduction of sugar. The first coffee-house was opened in London in 1652, and the first in France, at Marseilles, 1671.

CHAPTER XXVIII.

VEGETATION—*continued.*

§ 1. African flora. § 2. Flora of Australia, Norfolk Island, and New Zealand. § 3. Flora of Polynesia.

AFRICAN FLORA.

§ 1. THE northern coast of Africa, and the range of the Atlas generally, may be regarded as a zone of transition, where the plants of southern Europe and tropical Africa are mingled with those peculiar to the country. The majority of the plants of northern Africa are also found in the other countries on the shores of the Mediterranean. Of 60 trees and 248 shrubs which grow there, 100 only are peculiar to Africa, and about 18 of these belong to its tropical flora. There are about six times as many herbaceous plants as there are trees and shrubs; and in the Atlas mountains, as in other chains, the perennial plants are much more numerous than annuals. Evergreens predominate, and are the same as those on the other shores of the Mediterranean. The pomegranate, the locust-tree, the oleander, and the palmetto abound; and the cistus tribe give a peculiar character to the flora. The sandarach, or Callitris articulata, peculiar to the northern side of the Atlas mountains and to Cyrenaica, yields close-grained hard timber, used for the ceiling of mosques. The Atlas produces seven or eight species of oak, and various pines, especially the Pinus maritima; and forests of the Aleppo pine are found in Algeria. The sweet-scented arborescent heath and Erica scoparia are native here, also in the Canary Islands and the Azores. There are 534 phanerogamous plants in the Canary Islands; of these 310 are indigenous, the rest African; the Pinus canariensis is peculiar, and also the Dracæna draco, which grows in perfection here. The stem of the great dracæna mentioned by Humboldt, at the Villa Orotava in Teneriffe, measures 46 feet in circumference at the base of the tree, which is 75 feet high. It is known to have been an object of great antiquity in the year 1402, and is still alive, bearing blossoms and fruits. Though the group of the Canaries has plants in common with Spain, Portugal, Africa, and the Azores, yet there are many species, and even genera, which are found in them only; and the height of the mountains causes much variety in the vegetation.

On the continent S. of the Atlas a great change of soil and climate takes place; the drought on the borders of the desert is so excessive that no trees can resist it; rain hardly ever falls, and the scorching blasts from the S. speedily dry up any moisture that may exist; at the base of the mountains, however, the date-palm forms large forests, which supply the inhabitants with food, and give shelter to crops which could not otherwise grow. The date-palm, each tree of which yields from 150 to 160 pounds weight of fruit, grows naturally, and is also cultivated, through northern Africa.[1] It has been carried to the Canary Islands, Arabia, the Persian Gulf, and to Nice. Stunted plants are the only produce of the desert, yet large tracts are covered with the Pennisetum dichotomum, a harsh grass, which, together with the Alhagi maurorum, is a great source of the food of camels.

The commoner plants of Egypt are acacias, cassias, tamarisks, Nymphæa lotus, and cærulea; also the zizyphus or jujube, and various mesembryanthemums. The date-palm is found higher up the Nile than Thebes; it afterwards gives place to the dôm-palm, or Crucifera Thebaica, peculiar to this district, and singular as being one of the few palms that have a branched stem.

The vegetation of western tropical Africa is best known along the coast, where some affinity with that of India may be observed. It presents a remarkable uniformity, not only in orders and genera, but even in species, from the 16th degree of N. lat. to the river Congo in 6° S. lat. The most prevalent orders are the grasses and Leguminosæ, the Cyperaceæ, Rubiaceæ, and Compositæ. The Adansonia, or baobab of Senegal, is one of the most extraordinary vegetable productions; the stem is sometimes 34 feet in diameter, though the tree is rarely more than 50 or 60 feet high; it covers the plains so entirely with its umbrella-shaped top, that a forest of these trees presents a compact surface, which at some distance seems to be a green field. Cape Verd has its name from the numbers that conceal the barren soil under their spreading tops; some of them from their size were supposed to be the most ancient vegetable inhabitants of the earth; but their wood is so soft that this is very improbable. The Pandanus candelabrum, instead of growing crowded together in masses like the baobab, stands solitary on the equatorial plains, with its lofty forked branches ending in tufts of long stiff leaves.

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[1] The best dates are those grown near Tozzer in the Beled el Jerid, in lat. 34° N., a region which, like that of Jericho, once celebrated for its dates, has an extremely warm climate, supposed to be owing to its depression below the sea-level.

Numerous sedges give a character to this region, and, along with the grasses, cover boundless plains, waving in the wind like corn-fields, while other places are overgrown by forests of more gigantic grasses with branching stems.

Impenetrable thickets of mangrove cover the deltas of the rivers, and even grow so far into the water that their trunks are coated with shell-fish; but the pestilential exhalations render it almost certain death to botanize amid this luxuriance of nature.

Various trees of the Sapota order are peculiar to Africa; the butter-tree of the enterprising but unfortunate Mungo Park, the star-apple, the cream-fruit, the custard-apple, and the water-vine, are plentiful in Senegal and Sierra Leone. The safu and bread-fruit of Polynesia are represented here by the musanga, a large tree of the nettle tribe, the fruit of which has the flavour of the hazel-nut. A few palms have very local habitations, as the Elais guineensis, or palm-oil plant, found only on the coast. That graceful tribe is less varied in species in equatorial Africa than in the other tropical continents.

The flora of South Africa differs entirely from that of the northern and tropical zones, and as widely from that of every other country. The soil at the Cape of Good Hope, and of the Karroo plains and valleys between the mountains, is sometimes gravelly, but more frequently is composed of sand and clay; in summer it is dry and parched, and most of its rivers are dried up; it bears but a few stunted shrubs, some succulent plants and mimosas, along the margin of the river-courses. The sudden effect of rain on the parched ground is like magic; vegetation is recalled to life, and in a short time the country is decked with a beautiful and peculiar flora.

Several thousand species of plants have been collected in South Africa. Of these, Ericaceæ and Proteaceæ are two conspicuous orders; they are very limited in distribution; but few are to be seen N. of the mountains which bound the Great Karroo, and by much the greater number of them grow within 100 miles of Cape Town; indeed at the distance of only 40 miles the prevailing Proteaceæ are different from those of that locality. The Leucodendron argenteum, or silver-tree, which forms groves at the back of Table-mountain, is confined to the peninsula of the Cape. The beautiful Disa grandiflora is found only in one particular spot on the top of Table mountain.

The dry sand of the W. coast and the country northward, through many degrees of latitude, is the native habitation of stapelias, succulent plants with leafless stems, and flowers like star-fish, with the smell of carrion. A great portion of the eastern frontier of the Cape colony and the adjacent districts is covered with extensive thickets of a strong succulent and thorny vegetation called by the natives "the bush:" similar thickets occur again far to the W., on the banks of the river Guaritz. The most common plants of the bush are aloes of many species, all exceedingly fleshy and some beautiful: the great red-flowering arborescent aloe, and some others, make a conspicuous figure in the eastern part of the colony. Other characteristic plants of the eastern districts are the spek-boem, or Portulaca afra, Schottia speciosa, and the great succulent euphorbias, which grow into real trees 40 feet high, branching like a candelabrum, entirely leafless, prickly, and with a very acrid milky juice. The Euphorbia meloformis, three feet in diameter, lies on the ground, to which it is attached by slender fibrous roots, and is confined to the mountains of Graaf Reynet. The succulent euphorbias, in the Old World, represent the Cactus tribe, which belong exclusively to the New. Cycadeæ, having the appearance of dwarf-palms without any real similarity of structure, belong to the eastern districts, especially to the great tract of bush on the Caffir frontier.

Various species of Acacia are indigenous and much circumscribed in their location: the Acacia horrida, or white-thorned acacia, is very common in the eastern districts and in Caffirland. The Acacia cafra is strictly eastern, growing along the margins of rivers, to which it is a great ornament. The Acacia detinens, or hook-thorn, is almost peculiar to the Zand valley.

It appears from the instances mentioned that the vegetation of the eastern districts of the colony differs from that of the western, yet many plants of orders and genera found only in this part of Africa are generally diffused:—Nearly all the 300 species of the fleshy succulent tribe of Mesembryanthemum, or Hottentot's fig; a great many beautiful species of the Oxalis, or wood-sorrel tribe; every species of Gladiolus, with the exception of that in the corn-fields of Italy and France; ixias innumerable, one with petals of apple-green colour; geraniums, especially the genus Pelargonium, or stork's bill, almost peculiar to this locality; many varieties of Gnaphalium and Xeranthemum; the brilliant Strelitzia; 133 species of the house-leek tribe, all fleshy, attached to the soil by a strong wiry root, and nourished more or less from the atmosphere: Diosmas are widely scattered in great variety; shrubby Boragineæ with flowers of vivid colours, and terrestrial Orchideæ with large and showy blossoms. The leguminous plants and the Cruciferæ of the Cape are peculiar; indeed all the vegetation has a distinct character, and both genera and species are confined within narrower limits than is usual anywhere else, without any apparent cause to account for a dispersion so arbitrary.

Notwithstanding the peculiarity of character with which the botany of the Cape is so distinctly marked, it is connected with that of very remote countries by particular plants. The affinity with Australia is great: in portions of the two countries in the same latitude there are several genera identical: Proteaceæ and Restiaceæ are abundant in both, and comparatively very rare elsewhere. Irideæ, Leguminosæ, Diosmeæ, and some others, are also most characteristic of both floras.

The vegetation of Madagascar, though similar in many respects to the floras of India and Africa, nevertheless has great peculiarity. The Hydrogeton fenestralis, or lattice-leaf, a singular aquatic plant, with leaves like the skeletons of leaves, having no green substance between the veins; and the Tanghinia veneniflua, which produces a poison so deadly that its seeds are used to execute criminals, are natives of this country.

Some genera and species are common and peculiar to Madagascar, the Isle of Bourbon, and Mauritius. The three islands are rich in ferns. The Pandanus, or screw-pine genus, abounds in Bourbon and the Mauritius, where it covers sandy plains, sending off strong aërial roots from the stem, which strike into the ground and enable the plant to resist the violent winds.

Eight or 10 degrees N. of Madagascar lies the group of the Seychelles Islands, in one of which are groves of the peculiar palm which bears the double coco-nut, or coco de mer, the growth of this island only. Its gigantic leaves are employed in the construction of houses, and other parts of the plant are applied to various domestic purposes.

FLORA OF AUSTRALIA.

§ 2. The flora of the Australian continent is of a strange and unexampled character. Several entire orders of plants are known only in Australia, and the genera and species of families that grow elsewhere, here assume new and singular forms. Persistent-leaved trees, with hard narrow leaves of a sombre, melancholy hue, are prevalent, and there are whole shadowless forests of leafless trees; the foot-stalks of the leaves, dilated and set edgewise on the stem, supply their place, and perform the functions of nutrition; their altered position gives them a singular appearance. Plants in other countries have glands on the under side of the leaves, but in Australia there are glands on both sides of these substitutes for leaves, and the changes of the seasons have no influence on the unvarying olive-green of the Australian forests; even the grasses are to a great extent distinguished from those of other countries by a remarkable rigidity. These features are very much modified along the N. coast, which presents a less sombre character; but still the contrast of vegetation on the S. side of Torres Strait with the luxuriant jungle-clad shores of New Guinea, where deep and dark forests are rich in more than the usual tropical exuberance, is very great indeed. Mangrove swamps are found at the mouths of the rivers which flow into the Gulf of Carpentaria.

The peculiarly Australian vegetation is found in the southern part of the continent distributed in distinct foci in the same latitude, a circumstance of which the Proteaceæ afford a remarkable instance. Nearly one-half of the known species of this remarkable order grow in the parallel of Port Jackson, from which they decrease in number both to the S. and the N.; and the species of the south-western quarter of the continent are, without an exception, different from those of the eastern.

The myrtle tribe form a conspicuous feature in Australian vegetation, particularly the genera Eucalyptus, Metrosideros, Leptospermum, and others, some bearing splendid blossoms—white, purple, yellow, and crimson: 100 species of the Eucalypti, most of them large trees, grow in Australia, many of them forming extensive forests. The leafless acacias, of which there are 93 species, are prominent features in the Australian landscape. The genus Casuarina, with its strange jointed drooping branches, holds a conspicuous place; it is chiefly confined to the principal parallel of this vegetation, and produces excellent timber; it grows also in the Malayan peninsula and the South Sea islands. The Epacrideæ, with scarlet, rose, and white blossoms, supply the place of, and very much resemble, the true heaths, which do not exist here; the purple-flowering Tremandreæ; the yellow-flowering Dilleniaceæ; the Doryanthes excelsa, the most splendid of the lily tribe, 24 feet high, with a head of brilliant crimson blossoms, are all characteristic plants.

There is a change on the north-eastern coast of Australia. The Castanospermum australe is so plentiful that it furnishes the principal food of the natives; a caper-tree of grotesque form, having the colossal dimensions of the Senegal baobab, and extraordinary trees of the fig genus, characterize this region. It sometimes occurs here, as in other tropical countries, that the seeds of these fig-trees are deposited by birds on the branches of trees, that they vegetate and enclose the trunk entirely with their roots, sending up enormous lateral branches, which so completely envelop the tree, that at last its top alone is visible in the centre of the fig-tree. The Pandanus genus flourishes both inland and within the influence of the sea-air. There are several species of palms, equally local in their habitations as elsewhere, not one of which grows on the W. side of the continent. The Araucaria Cunninghamii produces the best timber of any tree in this part of Australia.

The south-western districts of Australia exhibit another focus of vegetation, less rich in species than that of Port Jackson, but even more peculiar. The Kingia australis rises solitary on the sandy plains, with tufts of long grassy leaves at the extremities of the bare trunks, which are blackened as if scathed by lightning, but in reality by the fires of the natives; Banksias are numerous; the Stylidium, whose blossoms are even more irritable than the leaves of the sensitive mimosa, and plants with dry, everlasting blossoms, characterize the flora of these districts. The greater part of the southern vegetation vanishes on the northern coasts of the continent, and what remains is mingled with the cabbage-palm, various species of the nutmeg tribe, sandal-wood, and other Malayan forms—a circumstance that may hereafter be of importance to our colonists. During Mr. Gregory's expedition in Western Australia he met with a very beautiful convolvulus, with numerous flowers from 2 to 3 inches in diameter, of a dark lilac deepening into a rich purple in the centre. It bears roots like a sweet potato, some of them more than a pound in weight and well flavoured, and forms an important article of food to the natives, and, if cultivated, it will be considered a valuable acquisition. A rock melon with fruit about the size of a pigeon's egg was met with also in great abundance.

Orchideæ, chiefly terrestrial, are in great variety in the extra-tropical regions of Australia. Reeds of gigantic size form forests in the marshes, and the kangaroo-grass covers the plains.

Beautiful and varied as the flora of Australia is, it is by no means luxuriant. There is little appearance of verdure, the foliage is poor, the forests often shadeless, and the grass thin; always excepting valleys of the eastern mountains, and even on some parts of the plains, where the vegetation is vigorous.

The flora of Tasmania is almost identical with that of South-Eastern Australia, especially the mountains of the Victoria colony. The plains glow with the warm golden flowers of the silver wattle, an acacia, the emblem of the island. Two tree-ferns grow in this country; of which one rises 40 feet to the base of the fronds, which spread into an elegant top, producing a shadow gloomy as nightfall; and there are also numerous species of orchideæ.

The botany of New Zealand appears to be allied to that of Australia, South America, and the Pacific Islands. Noble trees form impenetrable forests, 60 of which yield timber, and many are of kinds to which we have nothing similar. Here there are no representatives of our oak, birch, or willow, but five species of beech and ten of Coniferæ have been discovered that are peculiar to the country. The Kauri pine, or Dammara australis, is found only in the North Island, where it grows in hilly situations, shooting up with a clean stem 60 or 90 feet, sometimes 10 feet in diameter, and a spreading but thin top: it generally has a quantity of transparent yellow resin imbedded at its base. This fine tree does not grow beyond the 38th degree of S. lat. The Metrosideros tomentosa, with rich crimson blossoms, is one of the greatest ornaments of the coasts; and other species of the genus abound in the forests. One palm only inhabits New Zealand, the Areca sapida. This country is probably the southern limit of the orchideous plants that grow on trees. Before New Zealand was colonized, the natives used the roots of the edible fern, Pteris esculenta, with which some parts of the country is densely covered. More than 120 species of fern are natives of these islands, some of which are arborescent and 40 feet high; the country also produces the New Zealand flax, Phormium tenax, which grows abundantly both on the mountains and plains.

In Norfolk Island 152 species of plants are already known. The Cape gooseberry or Physalis edulis, the guava-tree, and lemon-trees, are introduced; also the bread-fruit tree, which blossoms, but does not bear fruit. The Araucaria excelsa and some palms are indigenous, and there are three times as many ferns as of all the other plants together.

§ 3. The multitude of islands of Polynesia constitute a botanical region apart from all others. The coco-nut palm and the pandanus are common to all, but the latter thrives only when exposed to the sea-air. This archipelago produces Tacca pinnatifida, which yields arrowroot; the Morus papyrifera, whose bark is manufactured into paper; and one of the Arum tribe, from which an intoxicating liquor is made. Fifty varieties of the bread-fruit tree are indigenous, which produce three or four crops annually. It is most abundant in the Friendly, Society, and Caroline groups, whence it has been taken to America, where it thrives in very low latitudes.

The Sandwich group is peculiar for the number of Lobelias; while the Coral islands, whose flora is entirely borrowed, rarely have two species belonging to the same genus; the fragrant Suriana and sweet-scented Tournefortia are among their scanty vegetation.

The two species of banana-trees which are natives of southern Asia, have been introduced at an unknown and probably early period into the Polynesian islands, and all tropical countries in the eastern and western hemispheres. Syria is their northern limit, where the Musa paradisiaca grows to 34° N. lat. The sweet fruit of these trees produces, on the same extent of ground, 44 times as much nutriment as the potato, and 133 times more than wheat.

St. Helena, Mauritius, the Sandwich group, New Zealand, Juan Fernandez, and above all the Galapagos islands, are more peculiar in their floras than any other tracts of their size. The Galapagos archipelago consists of 10 principal islands lying immediately under the equator, 600 miles from the coast of America. They are entirely volcanic, and contain 2000 extinct craters. The vegetation is so peculiar that, of 180 plants which have been collected, 100 are found nowhere else; of 21 species of Compositæ all but one are indigenous and belong to 10 genera, 8 of which are exclusively confined to these islands.

This flora has no analogy with that of Polynesia, but it bears a double relation to the flora of South America. The plants peculiar to the Galapagos islands are for the most part allied to those on the cooler part of the continent or on high lands, while the others are the same with those that abound in the hot damp, intertropical regions of the continent. The greatest number of peculiar plants grow on the tops of the islands where the sea vapour is condensed, and many of them are confined to some one islet of the group. Though this flora is singular it is poor compared with that of the Sandwich group, or the Cape de Verd Islands.

CHAPTER XXIX.

VEGETATION—*continued.*

§ 1. North American flora. § 2. Flora of Mexico and the West Indies. § 3. Flora of Tropical America. § 4. Flora of Extratropical South America. § 5. Antarctic flora. § 6. Origin and distribution of cerealia. § 7. Forest trees; their growth and longevity. § 8. Marine vegetation.

FLORA OF NORTH AMERICA.

§ 1. FROM similarity of physical circumstances the Arctic flora of America bears a strong resemblance to that of the northern regions of Europe and Asia. This botanical district comprises Greenland, and extends considerably to the S. of the arctic circle, especially at the eastern and western ends of the continent, where it reaches the 60th parallel of N. lat., and even more; it is continued along the tops of the Rocky Mountains almost to Mexico, and it reappears on the White Mountains and a few other parts of the Alleghanies.

Greenland has a much more Arctic flora than Iceland; the valleys present numerous mosses and marsh-plants, the gloomy rocks are sprinkled with sombre lichens, and the grasses on the pasture-grounds that line the fiords are nearly four times less varied than those of Iceland. In some sheltered spots the service-tree bears fruit, and birches grow to the height of a few feet; but ligneous plants in general trail on the ground.

Although the Arctic flora of America has much the same character as that of Europe and Asia, most of the species being common to all, there is yet a difference in the vegetation at the two extremities of the continent; there are 30 species in the E. and 20 in the W. which are not common to both. The sameness of character changes with the barren treeless lands at the verge of the arctic region, where the distribution of plants varies both with the latitude and the longitude. Taking a broad view of the botanical districts of North America, there are two woody regions, one on the eastern, the other on the western side of the continent, separated by a region of prairies where grasses and herbaceous plants predominate. The vegetation of these three parts, so dissimilar, varies with the latitude, but not after the same law as in Europe, for the winter is much colder and the summer warmer on the eastern coasts of America than on the western shores of Europe, owing in a great measure to the prevalence of westerly winds which bring cold and damp to our shores.

Boundless forests of black and white spruce, with an undergrowth of reindeer moss, cover the country S. of the arctic region, which still further S. are afterwards mixed with other trees. There are vast forests in Canada of pines, oak, ash, hickory, red beech, birch, the lofty Canadian poplar, sometimes 100 ft. high and 36 ft. in circumference, and sugar-maple; the prevailing shrubs are Kalmias, Azaleas, and Asters, the former vernal, the latter autumnal; solidagos and asters are the most characteristic plants of this region.

The splendour of the North American flora is displayed in the Eastern States; the American sycamore, chestnut, black walnut, hickory, white cedar, wild cherry, red birch, locust-tree, tulip-tree, or Liriodendron, the glory of American forests, liquidambar, oak, ash, pine-trees of many species, grow luxuriantly, with an undergrowth of Rhododendrons, Azaleas, Andromedas, Gerardias, Calycanthus, Hydrangea, and many more of woody texture, with an infinite variety of herbaceous and climbing plants.

The vegetation is different on the two sides of the Alleghany mountains; the locust-tree, Canadian poplar, Hibiscus, and Hydrangea, are most common on the W. side; the American chestnut and Kalmias are so numerous on the Atlantic side as to give a distinctive character to the flora: here, too, aquatic plants are more frequent: among these is the Sarracenia or side-saddle flower, singular in form, with leaves like pitchers covered with a lid, half full of water.

The autumnal tints of the forests in the States are beautiful and of endless variety; the dark leaves of the evergreen pine, the red foliage of the maple, the yellow beech, the scarlet oak, and purple Nyassa, with all their intermediate tints, ever changing with the light and distance, produce an effect at sunset that would astonish the native of a country accustomed to a more sober-coloured flora under a more cloudy sky.

In Virginia, Kentucky, and the southern States the vegetation assumes a different aspect, though many plants of more northern districts are mixed with it. Trees and shrubs here are remarkable for broad shining leaves and splendid blossoms, as the Gleditschia, Catalpa, Hibiscus, and the family of Magnolias. They are the distinguishing feature of the flora from Virginia to the Gulf of Mexico, and from the Atlantic to the Rocky Mountains: the Magnolia grandiflora and the tulip-tree are the most splendid specimens of this tribe of plants; the latter is often 120 feet high. The long-leaved pitch-pine, one of the most picturesque of trees, covers an arid soil on the coast of the Atlantic, of 60,000 square miles. The swamps so common in the southern States are clothed with the gigantic deciduous cypress, the aquatic oak, and swamp hickory, whilst the rare and magnificent Nelumbium luteum and other aquatics grow there; and among the innumerable herbaceous plants the singular Dionæa muscipula, or American fly-trap: the trap is formed by two opposite lobes of the leaf, edged with spines, and so irritable that they instantly close upon the insect that lights on them. This Magnolia region corresponds in latitude with the southern shores of the Mediterranean, but the climate is hotter and more humid, in consequence of which there is a considerable number of Mexican plants. A few dwarf-palms appear among the Magnolias, and the forests in Florida and Alabama are covered with Tillandsia usneoides, an air-plant, which hangs from the boughs.

Many species of grass cover the extensive prairies or steppes of the valley of the Mississippi. The forms of the Tartarian steppes appear to the N. in the Centaureas, Artemisias, Astragali; but many more are peculiar. The Helianthus and Coreopsis, mixed with some European genera, mark the middle regions; and in the south, towards the Rocky Mountains, Clarkia and Bartonia are mixed with the Mexican genera of Cactus and Yucca. The western forest is less extensive and less varied than the eastern, but the trees are larger. This flora in high elevations is but little known: the Thuja gigantea on the Rocky Mountains and the coast of the Pacific is 200 feet high. Claytonias and currants, with plants of northern Asia, are found here.

The forests of British Columbia and Vancouver's Island abound in Coniferæ, the red and yellow cedar and pines. The birch, the maple, and hazel are found in British Columbia, and oaks in the S. of Vancouver's Island. The wild-rose, sweet-briar, and berry-bearing bushes are numerous, and cranberries are so abundant that they are exported to San Francisco. Hemp and flax grow wild, and from the fibres of the Urtica Cannabina, the Indians manufacture twine, rope, and nets. The coast mountains of California have pine valleys in which the burr oak, with elm-like branches is a distinguishing tree. Oaks, pines, laurels, cypresses, the madrona, the mazanita and the gigantic redwood are found on the tops of the hills and in the close cañons. The timber of the redwood is used for building. The forests of the Sierra Nevada have a wide variety of oaks, pines, firs, cypresses, and cedars. The sugar pines are distinguished by huge cones hanging all over their tops. These trees are sometimes 300 feet high, and eight or ten feet in diameter; they furnish fine timber.

The Pinus Lambertiana is an instance of the stupendous trees of the western flora; many species of pine are indigenous in California, among which is the mammoth-tree, or Wellingtonia (*Sequoia gigantea*), which attains from 200 to 300 and even 325 feet in height, and 100 in girth, and some plants of which are supposed to be 2000 years old. The mammoth trees are scattered among the other trees of the forests at some eight different places along the side of the Sierra Nevada, at elevations of from 4000 to 7000 feet, and within a distance of a hundred and fifty miles S. of the centre of the state of California. None have been found out of this line. The Calaveras grove of Big Trees is the most northerly; the Mariposa grove, containing about 600 trees, 125 of which are over 40 ft. in circumference, and several from 90 to 100 ft, has been set apart to be preserved by the state. "The bark of these trees is of a light cinnamon colour, fluted up and down the long, straight, slowly-tapering trunk, like Corinthian columns in architecture; the top, resting like a cap upon a high bare mast, is a perfect cone; and the evergreen leaves wear a bright light shade, by which the tree can be distinguished from afar in the forest. The wood is a deep rich red in colour; the bark is sometimes as much as twenty inches thick."[1] This is the native soil of the currant-bushes with red and yellow blossoms, of many varieties of lupins, pæonies, eschscholtzias, and other herbaceous plants so ornamental in our gardens.

Amongst the native fruits of North America the hickories are the most celebrated, and there are many of these; to which may be added, in the Southern States, the Chicasaw plum, the papaw, the banana, the red mulberry, and the plumlike fruit of the persimon. There are several species of wild grapes, of which one produces an excellent wine, and is largely cultivated. North America has contributed much to the ornament of our pleasure-grounds and gardens, and has also borrowed largely from other parts of the globe. Tobacco, Indian corn, and many other plants of the utmost commercial value, are strangers to the soil, having been introduced by the earliest inhabitants from Mexico and South America.

FLORA OF MEXICO AND THE WEST INDIES.

§ 2. Mexico itself unites the vegetation of North and South America, though it resembles that of the latter most nearly. Whole provinces on the table-land and mountains produce alpine plants, oaks, chestnuts, and pines spontaneously.

The lowlands of Mexico and Central America have a very rich flora, consisting of many plants peculiar to them. The Hymenea

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[1] Bowle's "Our New West."

Courbaril, from which the copal of Mexico is obtained, logwood mahogany, and many other large trees, valuable for their timber grow in the forests; sugar-cane, tobacco, indigo, American aloe yam, capsicum, and yucca are indigenous in Mexico and Central America. It abounds in species of the Melastomas and Passiflora. The pine-apple is entirely American; it has been carried to and naturalised in all the tropical countries of the Old World. This country also produces the cherimoya, said to be the most excellent of fruits. Much of the vanilla which is used in Europe comes from the states of Vera Cruz and Oaxaca, on the eastern slopes of the Cordillera of Anahuac in Mexico. Hot arid tracts are covered with the Cactus tribe. They are social plants, inhabiting sandy plains in thickets, and of many species: their forms are various and their blossoms beautiful. A few occur at a considerable distance from the tropics, to the north and the south. An opuntia grows in the Rocky Mountains; and Sir George Back found a small island in the Lake of the Woods covered with it. In Mexico the cochineal insect was collected from the Cactus coccinellifer long before the Spanish conquest. There are large fields of American aloe, from which a fermented liquor called pulque, and also an ardent spirit, is made. The ancient Mexicans made their hemp from this plant, and also their paper. The forests of Panama contain at least 97 different kinds of trees, which grow luxuriantly in a climate where the torrents of rain are so favourable to vegetation, and so unfavourable to human life that the tainted air is deadly.

Maize or Indian corn is believed to have come originally from Mexico and South America. It is an annual, requiring only summer heat; its limit is 50° N. in the American continent, and 47° N. in Europe; it ripens at an elevation of 7600 feet in low latitudes, and in the lower Pyrenees at the height of 3289 feet.[1]

The flora of each West Indian island is similar to that of the continent opposite to it. The Myrtus pimento, producing allspice, the Custard-apple, Guava, Alligator pear, and Tobacco are indigenous.

FLORA OF TROPICAL AMERICA.

§ 3. The flora of tropical America is so varied that it is not possible to convey an idea of the peculiarities of this vegetation, or of the extent and richness of its woodlands. The upper Orinoco flows for some hundreds of miles chiefly through forests; and the forests of the Amazons are six times the size of France. In these the trees are colossal, and the vegetation so matted together by underwood, creeping and parasitical plants, that the sun's rays can scarcely penetrate the dense foliage.

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[1] In the island of Titicaca, in Peru-Bolivia, Mr. Pentland has seen a variety of maize ripen as high as 12,800 feet.

These extensive forests are by no means uniform; they differ to some extent on each side of the equator, though climate and other circumstances are similar. So partial is this splendid vegetation, that each of the great rivers has many species peculiar to its banks; particular families of plants predominate where they occur, and change the appearance of the forest. Thus, from the prevalence of the orders Laurineæ, Sapotaceæ, and others, which have leathery, shining, and entire leaves, the forests through which the Rio Negro, Cassiquiare, and Atabapo flow, differ in aspect from those on the other affluents of the Amazon. Even the grassy llanos, so uniform in appearance, have their centres of vegetation, and only agree with the pampas of Buenos Ayres in being covered with grass and herbs.

On the Andes, almost at the limit of vegetation, the ground is covered with purple, azure, and scarlet Gentians, Drabas, Alchemillas, and many other brilliantly coloured alpine plants. This zone is followed by thickets of coriaceous-leaved plants, in perpetual bloom and verdure; and then come the forest-trees. Arborescent ferns ascend to 7000 feet; the coffee-trees and palms to 5000; and neither indigo nor cacao can be cultivated higher than 2000. The tree yielding cacao, of which chocolate is made, grows wild in Guiana, Mexico, in the inland forests of Peru and Bolivia, and on the coast of Venezuela; it is now cultivated in Central and South America, and in the Philippine Islands, where it was introduced by the Spaniards. The seeds of its fruit, which is like a cucumber, are the cacao or chocolate bean.

Many parts of the coast of Venezuela and Guiana are rendered pestilential by swamps covered with mangroves. The well-known poison Ourari or Wourali is prepared by the Indians of Guiana from the fruit and bark of the Strychnos toxicaria, probably the most deadly plant which nature has produced. It is a creeping plant which yields this deadly juice, the powerful effect of which was first proved by Mr. Waterton's experiments.

The Cinchona, or true bark-tree, consisting of several species, is a native of the eastern declivities of the Andes,[1] but, under the direction of the Dutch government, it has been transplanted to

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[1] Dr. Weddell, a very distinguished English botanist, employed by the French government, who has explored the districts along the eastern declivities of the Peru-Bolivian Andes which furnish the Peruvian bark of commerce, has discovered several new species of Cinchona, the total number of which, according to his very interesting monograph, now amounts to 21.—(Weddell, 'Histoire Naturelle des Quinquinas,' 1 vol. folio, avec 34 planches, Paris, 1849.) And Mr. Howard has added some more in his additions to the 'Quinologia' of Pavon.

Java, where it is now cultivated, and still more recently by Mr. C. R. Markham, acting under the orders of the Council of India, into the hilly countries of southern India, and into Jamaica.[1] Some of its medicinal qualities are found in other plants of different genera in Guiana, as the Cusparia, which produces the Angostura bark. The Sapindus saponarius, or soap-tree, is used by the natives for washing. Capsicum, vanilla, and the cassava or mandioca, are natives of the country. There are two kinds of mandioca, a shrub whose fleshy roots yield a farina eaten by the natives of Spanish America and Brazil: the root of one (called Yuca in Peru) is harmless, but the other (Manihot utilissima) contains a poisonous milky juice, the effects of which are removed by the washing or pressure of the pulp. From the starch of the latter, tapioca is prepared. It grows to about 30° on each side of the equator, and to 3200 feet above the sea-level. An acre of mandioca is said to yield as much nourishment as six acres of wheat.

The arrowroot-plant is a native of the West India Islands, from which it has been transported to the East Indies and Ceylon. The flour is the produce of the roots of the Maranta arundinacea and M. Indica, natives of Bermuda and Jamaica. The substance owes its English name to the belief that the juice of the Marantas is an antidote to the poison of the arrows of the Indians. The cow-tree, almost confined to the mountains of the coast of Venezuela, yields an abundance of nutritious milky juice like that of a cow, which is preserved in gourds. The Theobromæ, or cacao-trees, fruits of the most excellent flavour, and plants yielding balsam, resin, and gum, are numerous in the tropical regions. There the laurel tribe assume the character of majestic trees; some are so rich in oil, that it gushes from a wound in the bark. One of these laurels produces the essential oil which dissolves caoutchouc, or Indian rubber, used in rendering cloth waterproof.

Palms are the most numerous and the most beautiful of all the trees in these countries. There are several hundred species of them; and they are so local that a change takes place every 50 miles. They are the greatest ornament of the upper Orinoco.

The llanos of Venezuela and Guiana are covered with high grass, mixed with lilies and other bulbous flowers, sensitive mimosas, and palms constantly varying in species.

No language can describe the glory of the forests of the Amazon and Brazil, the endless variety of form, the contrasts of colour and size: there even the largest trees bear brilliant blossoms; scarlet, purple, blue, rose-colour, and golden yellow, are blended with every possible shade of green. Majestic trees, as the Bombax ceiba (or silk-cotton tree), the dark-leaved mora with its white blossoms, the fig, cashew, and mimosa tribes, which are here of unwonted dimensions, and a thousand other giants of the forest, are contrasted with the graceful palm, the delicate acacia, reeds of 100 feet high, grasses of 40, and tree-ferns. Passifloræ and slender creepers twine round the lower plants, while others as thick as cables climb the lofty trees, drop again to the ground, rise anew, and stretch from bough to bough, wreathed with their own leaves and flowers, yet intermixed with the vividly-coloured blossoms of the Orchideæ. It may here be remarked that one of the most noticeable features in tropical forests is their prevailing greenness, for the leaves do not change their colours as in extra-tropical countries. Magnificent blossoms do occur, but there is no blaze of gorgeous colouring. An impenetrable and everlasting vegetation covers the ground; decay and death are concealed by the exuberance of life; the trees are loaded with parasites while alive—they become masses of living plants when they die. Here too occurs the Siphonia elastica, that invaluable tree whose juice, known under the name of India rubber, has become one of the most important substances in commerce.

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[1] See Mr. Markham's 'Travels in Peru and India while superintending the Collection of Cinchona Plants and Seeds in South America, and their Introduction into India.'

The forests on the banks of the Paraguay and Vermejo are almost as rich as those of the tropics. Noble trees furnish timber and fruit; the algaroba, a kind of acacia, produces clusters of a bean of which the Indians make bread, and also a strong fermented liquor; forests of the Copernicia cerifera, or wax-palm, grow there; and so does the yerba-maté, the leaves and twigs of which are universally used as tea in South America, and were in use before the Spanish conquest. It is a species of holly, with leaves three inches long.

The sandy deserts towards the mountains are the land of the cactus in all its varieties. Some larger species of cactus give a light and durable timber for building; and the cochineal insect, which feeds on one of them, is a valuable article of commerce.

FLORA OF EXTRATROPICAL SOUTH AMERICA.

§ 4. Grass, clover, European and African thistles, which have been introduced, are the almost unvarying features of the pampas; and thorny stunted bushes, characteristic of all deserts, are the only vegetation of the Patagonian shingle. But in the mountain valleys in the far S. may be seen the winter's bark, beech-trees, stunted berberries, and numerous trees and shrubs.

Large forests of Araucaria imbricata grow on the sides of the Andes of Chili and Patagonia. This tall and handsome pine, with cones the size of a child's head, supplies the natives with a great part of their food. It is said that the fruit of one large tree will maintain eighteen persons for a year.

Nothing grows under these great forests; and when accidentally burnt down in the mountainous parts of Patagonia, they never rise again, but the ground they grew on is soon covered with an impenetrable brushwood of other plants. In Chili the violently stinging Loasa appears first in these burnt places, bushes grow afterwards, and then comes a tree-grass, 18 feet high, of which the Indians make their huts. The vegetation that springs up after the burning of so-called primæval forests is accounted for by some on the hypothesis that seeds of the plants in question had remained for ages buried in the soil, but by more cautious naturalists it is attributed to the agency of the animal creation and winds, which are ever transporting seeds to localities favourable to their propagation. The former is probably the true explanation, for in the first instance the vegetation is of one species, as the Loasa in Chili, and it is well known that seeds will germinate after being kept for ages.

The southern coasts of Chili are very barren, and all plants existing there, even the herbaceous, have a tendency to assume a hard knotty texture. The stem of the wild potato, which is indigenous in Chili, becomes woody as it grows old. It is a native of the sea-strand, and is never found naturally more than 400 feet above it. In its wild state the tuber is small and bitter; it is one of many instances of the influence of cultivation in rendering unpromising plants useful to man. It was cultivated in America at the time of its discovery, and is so now, at the height of from 9800 to 13,000 feet above the sea on the Andes, and as high as 4800 feet on the Swiss Alps; it rarely succeeds on the plains in hot countries, nor farther N. than Iceland. It had been introduced into Europe by the Spaniards before the time of Sir Walter Raleigh; he brought it to England from Virginia in 1586.

Coca, the Erythroxylon coca of botanists, is a native of the tropical valleys on the eastern declivity of the Andes of Peru and Bolivia, where it is extensively cultivated for its leaf, of which the tree furnishes three or four crops annually; the coca-leaf is chewed by the aborigines mixed with an alkaline substance: it acts as a stimulant like opium; it is an article of great trade, being used by the aboriginal population of the Andes and the Upper Amazons.

Between the southern parallels of 38° and 45° Chili is covered with extensive forests—stately trees of many kinds, having smooth and brightly-coloured trunks bound together by parasitical plants; large and elegant ferns are numerous, and arborescent grasses entwine the trees to the height of 20 or 30 feet; palm-trees grow to the 37th parallel of latitude, which appears to be their southern limit.

Although the flora, at an elevation of 9000 feet on the Chilian

Andes, is almost identical with that about the Strait of Magellan, yet the climate is so mild in some valleys, that of Antuco for example, that the vegetation is semi-tropical. In it broad-leaved and bright-coloured plants, and the most fragrant and brilliant Orchideæ, are mixed with the usual alpine genera.

The humidity or dryness of the prevailing winds makes an immense difference in the character of the countries on each side of the Andes. Within the southern tropic the trade-winds come loaded with vapour from the Atlantic, which is partly precipitated by the mountains of Brazil, and supplies the noble forests of that country with never-ceasing moisture, while the remainder is condensed by the Andes; so that on their eastern side there is an exuberant vegetation, while on the western declivities and in the space which separates them from the Pacific the land is almost barren, and on the plains and in the valleys of Peru, where rain very seldom falls, completely so, except where artificial irrigation is employed. Even on the eastern side of these mountains the richness of the vegetation gradually disappears with the increasing height, till at an elevation of about 15,000 feet arborescent plants vanish, and alpine races, of the most vivid beauty, succeed; these in their turn give place to grasses at the height of 16,000 feet. Above that limit are dreary plains where even the thinly-scattered mosses are sickly; and at a height exceeding 20,000 feet the snow-lichen forms the last show of vegetable life on the rocky peaks projecting from the snow.

ANTARCTIC FLORA.

§ 5. Kerguelen Land and Tierra del Fuego are the northern boundary of the antarctic lands, which are scattered round the S. pole at immense distances from one another. On these the vegetation decreases as the latitude increases, till all but utter desolation prevails, long before reaching the Polar circle; beyond this not a lichen covers the dreary storm-beaten rocks; and, with the exception of a few microscopic marine plants, not a sea-weed lives in the gelid waves. In the arctic regions, on the contrary, no land has yet been discovered that is entirely destitute of vegetable life. This remarkable difference does not so much depend on a greater degree of cold in winter as on the want of warmth in summer. In the high northern latitudes the power of the summer sun is so great as to melt the pitch between the planks of the vessels; while in corresponding southern latitudes the thermometer does not rise above 14° Fahr. at noon at a season corresponding to our August. The perpetual snow reaches to a much lower latitude in the southern lands than it does in the N. Sandwich-Land, in a latitude corresponding to that of the N. of Scotland, is in parts perpetually covered with snow. A single species of grass, the Aira antarctica, is the only flowering plant in the South Shetland group, which is no less ice-bound; and Cockburn Island, which forms a part of it, in the 60th parallel, contains the last vestiges of vegetation; while the Shetlands in our hemisphere, in an equally high latitude, are inhabited and cultivated: nay, South Georgia, in a latitude similar to that of Yorkshire, is always clad in frozen snow, and only produces some mosses, lichens, and one or two herbaceous plants; while Iceland, 10 degrees nearer the pole, has 870 species, more than half of which are flower-bearing.

The forest-covered islands of Tierra del Fuego are only 360 miles from the desolate South Shetland group: such is the difference that a few degrees of latitude can produce in these antarctic regions, when combined with an equable climate and excessive humidity. The prevalence of evergreen plants is the most characteristic feature in the Fuegian flora. Densely tangled forests of beech-trees grow from the shore to a considerable height on the mountains. Of these the Fagus betuloides, which never loses its leaves, prevails almost to the exclusion of the evergreen winter's bark and the deciduous beech, which is very beautiful. There are dwarf species of Pernettya, the Myrtus nummularia, which is used instead of tea, besides berberry, currant, and fuchsia; peculiar species of Ranunculus, Calceolarias, Caryophylleæ, cruciform plants, and violets. Wild celery and scurvy-grass are abundant; and a bright yellow fungus, which grows on the beech-trees, forms a great part of the food of the natives. There is a greater number of plants in Tierra del Fuego either identical with those in Great Britain, or representatives of them, than exists in any other country in the southern hemisphere. The sea pink, or thrift, the common crowberry-wort, Primula farinosa, and at least 30 other flowering plants with almost all the lichens, 48 mosses, and many other plants of the cryptogamous kind, are identical, while a number of genera common to both countries, though unknown in the intermediate latitudes, reappear here. An alpine flora, many of the species of European genera, grows on the mountains, succeeded higher up by mosses and lichens.

Although the Falkland Islands are in a lower latitude than Tierra del Fuego, not a tree is to be seen. The Veronica elliptica, resembling a myrtle, which is extremely rare and confined to West Falkland, is the only large shrub. A white-flowering plant like the aster, about four feet high, is common; while a bramble, a crowberry, and a myrtle, bearing no resemblance, however, to the European species, trail on the ground and afford edible fruit. The bog balsam, or Bolax glebaria, and the Dactylis cæspitosa, or tussac grass, form the only conspicuous features in the botany of these islands, and grasses cover them, almost to the exclusion of other plants. The bolax grows in tufted hemispherical masses, of a yellow-green colour and very firm substance, often four feet high, and as many in diameter, whence a strong-smelling resinous substance exudes, the odour of which is perceptible at a distance. This plant has umbelliferous flowers, but forms an alpine and antarctic genus quite peculiar.

The tussac grass is the most useful and the most singular plant in this flora. It covers all the small islands of the group, and thrives best on the shores exposed to the spray of the sea. Each tussac is an isolated plant, occupying about two square yards of ground. It forms a hillock of matted roots, rising straight and solitary out of the soil, often six feet high and four or five in diameter, from the top of which it throws out a thick grassy foliage of blades, six feet long, drooping on all sides, and forming, with the leaves of the adjacent plants, an arch over the ground beneath, which yields shelter to sea-lions, penguins, and petrels. Cattle are exceedingly fond of this grass, which yields annually a much greater supply of excellent fodder than the same extent of ground would do either of common grass or clover. Both the tussac-grass[1] and the bolax are found, though sparingly, in Tierra del Fuego; indeed, the vegetation of the Falkland Islands consists chiefly of the mountain plants of that country and of those that grow on the arid plains of Patagonia; but it is kept close to the ground by the fierceness of the terrific gales that sweep over these antarctic islands. Peculiar species of European genera are found here, as a wood-sorrel and a yellow violet; while the Cardamine hirsuta, and the Primula farinosa, appear to be identical with those at home. In all, there are scarcely 120 flowering plants, including grasses. Ferns and mosses are few, but lichens are in great variety and abundance, among which many are identical with those in Britain.

The flora of Campbell's Island and the Auckland group is so intimately allied to that of New Zealand, that it may be regarded as the continuation of the latter, under an antarctic character, though destitute of the beech and pine trees. There is a considerable number of Fuegian plants in the islands under consideration, though they are 4000 miles distant; and whenever their flora differs in the smaller plants from that of New Zealand, it approximates to that of Antarctic America; but the trees and shrubs are entirely dissimilar. The relation between this vegetation and that of the northern regions is but slight. The Auckland group and Campbell's Island are in a latitude corresponding to that of England, yet only three indigenous plants of our island have been found in them, namely, the Cardamine hirsuta, Montia, and Callitriche. This is the utmost southern limit of tree-ferns.

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[1] The cultivation of this useful plant has been introduced into some of the western islands of Scotland, especially Lewis, by the praiseworthy efforts of its proprietor, Sir James Matheson, M.P. It thrives well in peaty soils within the influence of the sea-spray.

The Auckland Islands lie in the boisterous ocean S. of New Zealand. They are covered with dense and all but impenetrable thickets of stunted trees, or rather shrubs, about 20 or 30 feet high, gnarled by gales from a stormy sea. There is nothing analogous to these shrubs in the northern hemisphere; but the Veronica elliptica, a native of Tierra del Fuego and New Zealand, is one of them. Fifteen species of ferns find shelter under these trees, and their fallen trunks are covered with mosses and lichens. Eighty flowering plants were found during the stay of the Antarctic expedition, of which 56 were then new to science; many are peculiar to this group and to Campbell's Island, but the greater proportion are natives of the mountains of New Zealand. Some of the most beautiful flowers grow on the mountains, others are mixed with the ferns in the forests. A beautiful plant was discovered, like a purple aster; a veronica, with large spikes of ultramarine colour; a white one, with a perfume like jessamine; a sweet-smelling alpine Hierochloe; and in some of the valleys the fragrant and bright-yellow blossoms of a species of asphodel were so abundant as to be visible to ships sailing along the coast. There are also antarctic species of European genera, as beautiful red and white gentians, geraniums, &c. The landscape, though picturesque, has a sombre aspect, from the prevalence of brown dark evergreen-leaved plants.

Campbell's Island lies 120 miles to the S. of the Auckland group, and is much smaller, but from the more varied form of its surface it is supposed to produce as many species of plants. During the two days the discovery ships under the command of Sir James Ross remained there, between 200 and 300 were collected: of these 66 were flowering plants, and 14 were peculiar to the country. Many of the Auckland Island plants were found here, yet a great change had taken place; 34 species had disappeared, and were replaced by 20 new, all peculiar to Campbell's Island, and some were found that hitherto had been supposed to belong to Antarctic America only.

Perhaps no spot in either hemisphere, at the same distance from the Pole, is more barren than Kerguelen Land, lying in a remote part of the south polar ocean. Only 18 species of flowering plants were found there, which is less than the number in Melville Island, in the Arctic Seas, and three times less than the number in Spitzbergen. The whole known vegetation of this island only amounts to 150 plants, including seaweeds. The Pringlea, a kind of cabbage, acceptable to those who have been long at sea, is peculiar to the island, and grass, together with a plant similar to the bolax of the Falkland Islands, covers large tracts. About 20 mosses, lichens, &c., only are found in this island, but many of the others are also native in the European Alps and north polar regions. It is a very remarkable circumstance in the distribution of plants, that there should be so much analogy between the floras of places so far apart as Kerguelen Land, the groups S. of New Zealand, the Falkland Islands, South Georgia, and Tierra del Fuego.

ORIGIN AND DISTRIBUTION OF CEREALIA.

§ 6. The plants which the earth produces spontaneously are confined within certain districts; nevertheless Providence has endowed those most essential to man with so much power of adapting themselves to changes of climate and locality that the limits of their production can be extended by culture beyond what have been assigned to them by nature. The grasses yielding the grains are especially favoured in this respect, though their extension depends upon the knowledge and industry of man; so that with regard to useful plants there is an artificial as well as a natural boundary The cultivation of plants in gardens and hot-houses is entirely artificial, and depends on luxury and fashion.

Tartary and Persia are presumed to have been the original countries of wheat and rye, and the Caucasus that of oats; but these grains have been so long in use that it is impossible to trace their origin with certainty. In high northern latitudes wheat is protected from the inclemency of winter by sowing it in spring, or if sown in autumn a coating of snow defends it: the polar limit is the isothermal line of 57° 2′, and wheat will not form seed within the tropics, except at a considerable height .above the sea. In America the northern limit is unknown, the country being uninhabited; but at Cumberland House, in the very middle of the continent, one of the stations of the Hudson Bay Company, in 54° N. lat., wheat, barley, and maize are grown. Wheat thrives luxuriantly in Chili and Peru, and at elevations of 8500 and 10,000 feet above the sea. It even produces grain on the banks of the lake Titicaca, in the Peru-Bolivian Andes, at the absolute height of 12,900 feet, in sheltered situations, and good crops of barley are raised in that elevated region.

Barley bears cold better than any of the grains, yet neither it nor any other will grow in Iceland. It is successfully cultivated in the Faroë Islands; near North Cape, the extreme point of Norway near Archangel on the White Sea; and in Central Siberia to between 58° and 59° N. lat.

Rye is only cultivated where the soil is very poor, and agriculture little understood; yet a third of the population of Europe lives on rye-bread, chiefly inhabitants of the middle and especially of the northern parts: its limit is about the 67th parallel of N. latitude.

Oats are scarcely known in middle and southern Europe; in the N. they are extensively cultivated to the 65th degree of N. latitude.

Rice is the food of a greater number of human beings than any other grain: it has been cultivated from such high antiquity that all traces of its origin are lost. It contains less nutritious matter than any of the Cerealia, and, since it requires excessive moisture, and a temperature of 73°·4 at least, its cultivation is limited to countries between the equator and the 45th parallel.

Indian corn and millet are much cultivated in Europe S. of the 45th and 47th parallels, and form important articles of food in France, Italy, Africa, India, and America. Buckwheat is extensively cultivated in northern Europe and Siberia, and in central Asia; it is a native of Asia, whence it was brought into Europe in the 15th century.

The Cerealia afford remarkable examples of numberless varieties arising from the seed of one species. In Ceylon alone there are 160 varieties of rice, and at least 30 of millet. The endless variety which may be raised from the seed of one plant is more conspicuous in the flower-garden: the rose affords above 1400; the varieties of the pansy, calceolaria, tulip, auricula, and primrose are without end, and often differ so much from the parent plant that it seems almost impossible they should have had a common origin: it seems difficult to believe that red cabbage, cauliflower, and many others should have sprung from the Brassica oleracea, so totally dissimilar from any of them, with its bitter sea-green curly leaves. Fashion changes so much with regard to plants that it is scarcely possible to form even an approximation to the number known to be in cultivation: new plants are introduced from a foreign country, and are apt to take the place of some of the older, which are neglected and sometimes lost; of 120,000 plants which are known to exist on the earth, not more than 15,000 are believed to be in cultivation.

It is supposed that plants capable of bearing a great range of temperature would exist through longer geological periods than those more limited in their endurance of vicissitudes of heat and cold.

FOREST-TREES.

§ 7. Since forest-trees increase by coatings from without, the growth of each year forming a concentric circle of wood round that of the previous year, the age of a tree may be ascertained by counting the number of rings in a transverse section of the trunk, each ring representing a year. Moreover the progress of the growth is known by comparing the breadth of the rings, which are broader in a favourable than in an unfavourable season, though this may depend also in some measure on the quality of the soil which the roots have come to in their downward growth. If the number of concentric rings in a transverse section has shown the age of a tree, and its girth has been ascertained by measurement, an approximation to the age of any other tree of the same kind still growing, under similar circumstances, may be determined by comparison. In this way the age of many remarkable trees has been ascertained. The yew attains a greater age than any other tree in Europe. According to M. de Candolle this tree increases in girth the twelfth part of an inch in a year during the first 150 years, and rather less in the next 100, the increase probably decreasing progressively. By that estimate a yew at Fountains Abbey was reckoned to be 1214 years old; one at Crowhurst, in Surrey, was 1400 years old when measured by Evelyn; it has been shown by the same method that a yew at Fortingal, in Scotland, was between 2500 and 2600 years old; and one at Braburn, in Kent, must have been 3000 years old: these are the veterans of European vegetation.[1]

The cypress rivals the yew in longevity, and may perhaps surpass it. There is a cypress in the palace garden at Granada which was celebrated in the time of the Moors, and was still known, in the year 1776, as Cipres della Regina Sultana, because a sultana met with Abencerrages under its shade. M. Alphonse de Candolle estimates a deciduous cypress in the churchyard of Santa Maria de Tecla, near Oaxaca in Mexico, to be 6000 years old, Zuccarini 3572, and Dr. Lindley only 870. Oaks come next in order: they are supposed to live 1500 or 1600 years. One in Welbeck Lane, mentioned by Evelyn, was computed to be 1400 years old. Chestnut-trees are known to live 900 years; lime-trees have attained 500 or 600 years in France; and birches are supposed to be equally durable. Some of the smaller and less conspicuous European plants perhaps rival these giants of the forest in age. Ivy is an example of this; there is one near Montpellier, six feet in girth, which must be 485 years old. A lichen was watched for 40 years without the appearance of change.

The antiquity of these European trees has been supposed to be insignificant when compared with the celebrated Baobab, or Adansonia digitata, in Senegal; taking as a measure the number of concentric rings counted on a transverse incision made for the purpose in the trunk of that enormous tree, it was calculated to be 5150 years old.[1] Baron Humboldt considered a cypress in the garden of Chapultepec to be still older; it had already reached a great age when Montezuma was on the throne of Mexico, in 1520. Eight olive-trees on the Mount of Olives are supposed to be 800 years old; it is at least certain that they existed prior to the taking of Jerusalem by the Turks. There is some doubt as to the age of the largest cedar on Lebanon; it is nine feet in diameter, and has probably existed 800 or 900 years.

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[1] It is worthy of remark that the trees which in our temperate latitudes attain the greatest age belong to the family of the Coniferæ, which have furnished the most ancient vegetable remains imbeded in the strata which form the earth's surface, the oldest fossil plants of the Devonian and Carboniferous series belonging to trees nearly allied to Araucaria.

MARINE VEGETATION.

§ 8. A vegetable world lies hid beneath the surface of the ocean, altogether unlike that on land, and existing under circumstances totally different with regard to light, heat, and pressure, yet sustained by the same means. Carbonic acid is as essential, and metallic oxides are as indispensable, to marine vegetation as they are to land-plants. Sea-water contains a minute proportion of carbonic acid gas,[2] and something more than a twelve-thousandth part of its weight of carbonate of lime, yet that is sufficient to supply all the shell-fish and coral-insects in the sea with materials for their habitations, as well as food for vegetation. Marine plants are more expert chemists than we are, for the water of the ocean contains rather less than a millionth part of its weight of iodine, which they collect in quantities impossible for us to obtain otherwise than from their ashes.

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[1] Doubts have been expressed by some eminent botanists regarding the great age of the Adansonia digitata: the opinion given in the text is that of the late M. de Candolle, who says, "The baobab is the most celebrated instance of extreme longevity which has hitherto been noticed with any degree of accuracy; in its own country it bears a name which signifies 1000 years, and, contrary to what is usual, this name expresses what in reality is short of the truth." Adanson has noticed one in the Cape Verd Islands which had been observed by two English travellers three centuries earlier; he found within its trunk the inscription they had engraved covered over by 300 woody layers, and was thus enabled to estimate the bulk this enormous plant had increased in three centuries; it was on such data that De Candolle formed his opinion, which has been adopted by Humboldt and other eminent naturalists, and from which we see no reason to differ.—See, for a very learned view of the contrary opinion, the 'Gardener's Chronicle' for 1849, p. 340, the arguments of which would probably have convinced M. de Candolle, who was not aware of the excessively rapid growth and soft tissue of the baobab, nor that in many tropical trees several concentric layers of wood may be formed in one year.

[2] M. Laurens has found $\frac{1}{3000}$ part of this gas in the water of the Mediterranean.

Seaweeds fix their roots to anything—to stone, wood, and to other seaweeds; they must, therefore derive all their nourishment from the water, and the air it contains; and the vital force or chemical energy by which they decompose and assimilate the substances fit for their maintenance is the sun's light.

Marine plants, which are very numerous, consist of two groups—a jointed kind, which include the Confervæ, or plants having a thread-like form; and a jointless kind, to which belong dulse, laver, the kinds used for making kelp, iodine, vegetable glue, and all the gigantic species which grow in submarine forests, or float like green meadows in the open sea. Some species are found in every climate from pole to pole. No doubt the currents at the surface, and the stratum of uniform temperature lower down, are the highways by which these cosmopolites travel.

Marine vegetation follows a different law from that of the land, for it is neither so varied in form, so rich in colour, nor in such abundance between the tropics as in the temperate zones, and there are fewer vegetable provinces in the seas than on shore, because the temperature is more uniform, and the dispersion of plants is not so much interfered with by the various causes which disturb it on land.[1]

Marine vegetation varies both horizontally and vertically with the depth, and it seems to be a general law throughout the ocean that the light of the sun and vegetation cease together; it consequently depends on the power of the sun and the transparency of the water; so different kinds of seaweeds affect different depths, where the weight of the water, the quantity of light and heat, suit them best. One great marine zone lies between the high and low water marks, and varies in species with the nature of the coasts, but exhibits similar phenomena throughout the northern hemisphere. In the

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[1] Professor Harvey of Dublin has divided the marine vegetation into 10 provinces:—the Northern Ocean, from the Pole to the 60th parallel of north latitude;—the North Atlantic, between the 60th and 40th parallels, which is the province of the delesseriæ and fucus proper;—the Mediterranean, which is a sub-region of the warmer temperate zone of the Atlantic, lying between the 40th and 23rd northern parallels;—the tropical Atlantic, in which sargassum, rhodomelia, corallinia, and siphonea abound;—the antarctic American region, from Chili to Cape Horn; the Falkland Islands;—and the whole circumpolar ocean south of the 50th southern parallel;—the Australian and New Zealand province, which is very peculiar, being characterized, among other generic forms, by cystoseiriæ and fuceæ;—the Indian Ocean and the Red Sea;—and the last, which comprises the Japan and China Seas. There are several undetermined botanical marine provinces in the Pacific and elsewhere.

British seas, where, with two exceptions, the whole flora is cryptogamic,[1] this zone does not extend deeper than 30 fathoms, but is divided into two distinct provinces, one to the south and another to the north. The former includes the southern and eastern coasts of England, the southern and western coasts of Ireland, and both the channels: while the northern flora is confined to the Scottish seas and the adjacent coasts of England and Ireland. The second British zone begins at low-water mark, and extends below it to a depth from 7 to 15 fathoms. It contains the great tangle seaweeds, growing in miniature forests, mixed with fuci, and is the abode of a host of animals. A coral-like sea-weed is the last plant of this zone, and the lowest in these seas, where it does not extend below the depth of 60 fathoms, but in the Mediterranean it is found at 70 or 80 fathoms, and is the lowest plant in that sea. The same law prevails in the Bay of Biscay, where one set of seaweeds is never found lower than 20 feet below the surface; another only in the zone between the depths of 5 and 30 feet; and another between 15 and 35 feet. In these two last zones they are most numerous; at a greater depth the kinds continue to vary, but their numbers decrease. The seeds of each kind float at the depth most genial to the future plant: they must, therefore, be of different weights. The distribution in the Egean Sea was found by Professor E. Forbes to be perfectly similar, only that the vegetation is different, and extends to a greater depth in the Mediterranean than in more northern seas.[2] He also observed that seaweeds growing near the surface are more limited in their distribution than those that grow lower down, and that with regard to vegetation depth corresponds with latitude as height does on land. Thus the flora at great depths, in warm seas, is represented by kindred forms in higher latitudes.

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[1] The only British flowering plants that inhabit the ocean are Zostera and Zanichellia.

[2] The vegetation at different depths in the Egean Sea is as distinctly marked as that at different heights on the declivity of a mountain. The coast plants are the Padina pavonia and Dictyota dichotoma. A greater depth is characterized by the vividly green and elegant fronds of the Caulerpa prolifera, probably the prasium of the ancients; associated with it are the curious spongelike Codium bursa, and four or five others. The Codium flabelliforme, and the rare and curious vegetable net called Microdictyon umbilicatum, characterize depths of 30 fathoms. The Dictyomenia, with stiff purple corkscrew-like fronds, and some others, go as low as 50 fathoms, beyond which no flexible seaweeds have been found. The coral-like Millepora polymorpha take their place, and range to the depth of 100 fathoms, beyond which there was found no trace of vegetable life, unless some of the minute and microscopic infusorial bodies living there be regarded as plants.—'Travels in Lycia,' by Lieutenant Spratt, R.N., and Professor E. Forbes.

There is every reason to believe that the same laws of distribution prevail throughout the ocean and every sea.

Seaweeds adhere firmly to the rocks before their fructification, but they are easily detached afterwards, which accounts for some of the vast fields of floating weeds; but others, of gigantic size and wide distribution, are supposed to grow unattached in the water itself. There are permanent bands of seaweed in the British Channel and in the North Sea, of the kind called Fucus filum, which grow abundantly on the western coast of the Channel; they lie in the direction of the currents, in beds 15 or 20 miles long, and not more than 600 feet wide. The sebands must oscillate with the tides between two corresponding zones of rest, one at the turn of the flood, and the other at the turn of the ebb. It is doubtful whether the Fucus natans or Sargassum bacciferum grows on rocks at the bottom of the Atlantic, between the parallels of 40° N. and S. of the equator, and, when detached, is drifted uniformly to particular spots which never vary, or whether it is propagated and grows in the water; but the mass of that plant W. of the Azores occupies an area equal to that of Germany, and has not changed its place since the time of Columbus. Fields of the same kind cover the sea in the South Pacific, near the Bahama Islands and other places, and two new species of it were discovered in the Antarctic seas.

The Macrocystis pyrifera and the Laminaria radiata are the most remarkable of marine plants for their gigantic size and the extent of their range. They were met with on the Antarctic coasts two degrees nearer the S. pole than any other vegetable production, forming, with one remarkable exception, the utmost limit of vegetable life in the south polar seas. The Macrocystis pyrifera exists in vast detached masses, like green meadows, in every latitude from the south polar ocean to the 45th degree of N. lat. in the Atlantic, and to the shores of California in the Pacific, where there are fields of it so impenetrable that it has saved vessels driven by the heavy swell towards that shore from shipwreck. It is never seen where the temperature of the water is at the freezing-point, and is the largest of the vegetable tribe, being occasionally 300 or 400 feet long. The Laminaria abounds off the Cape of Good Hope and in the Antarctic Ocean. These two species form great part of a band of seaweed which girds Kerguelen Land so densely that a boat can scarcely be pulled through it; they are found in great abundance on the coasts of the Falkland group, and also in vast fields in the open sea, hundreds of miles from any land: had it ever grown on the distant shores, it must have taken ages to travel so far, drifted by the wind, currents, and the scud of the seas. The red, green, and purple lavers of Great Britain are found on the coasts of the Falkland Islands; and though some of the northern seaweeds are not met with in the intervening warm seas, they reappear here. The Lessonia is the most remarkable marine plant in this group of islands. Its stems, much thicker than a man's leg, and from 8 to 10 feet long, fix themselves by clasping fibres to the rocks above high-water mark. Many branches shoot upwards from these stems, from which long leaves droop into the water like willows. There are immense submarine forests off Patagonia and Tierra del Fuego, attached to the rocks at the bottom. These plants are so strong and buoyant that they bring up large masses of stone; and, as they grow slanting, and stretch along the surface of the sea, they are sometimes 300 feet long. The quantity of living creatures which inhabit these marine forests and parasitical weeds attached to them is inconceivable; they absolutely teem with life. Of the species of marine plants which are strictly antarctic, including those in the seas of Tasmania and New Zealand, Dr. Hooker has identified one-fifth with the British Algæ.

The higher latitudes of the Antarctic Ocean are not so destitute of vegetation as was at first believed. Most minute objects, altogether invisible to the naked eye, except in mass, and which were taken for silicious shelled animalcules of the infusorial kind, prove to be vegetable. They are a species of the Diatomaceæ, which, from their multitudes, give the sea a pale ochreous brown colour. They increase in numbers with the latitude, up to the highest point yet attained by man, and no doubt afford food to many of the minute animals in the antarctic seas. Genera and species of this plant exist in every sea from Victoria Land to Spitzbergen. It is another of the remarkable instances of a great end being effected by small means; for the silicious shells of this antarctic vegetation are forming a submarine bank between the 76th and 78th parallels of south latitude, and from the 165th to the 160th western meridian.

Great patches of Confervæ are occasionally met with in the open seas. Bands several miles long, of a reddish-brown species, like chopped hay, occur off Bahia, on the coast of Brazil: and different species are common in the South Pacific Ocean.

CHAPTER XXX.

DISTRIBUTION OF INSECTS.[1]

§. 1 Number of the species of insects; their uses; increase in species and number from the poles to the equator. § 2. Different insects found under the same parallels of latitude; mountain-chains form barriers to insect distribution; prevalence of insects dependent on soil and winds; effects of temperature and elevation on insect life. § 3. Development of insects dependent on condition of plants, as well as on particular species. § 4. Most universally distributed insects—common fly, mosquitoes, and gnats; prevalence of tormenting insects in some regions; the Tsetse-fly peculiar to tropical S. Africa. § 5. Honey-bees, fire-flies, scorpions, ants, and spiders. § 6. Migration of insects. § 7. Infusoria.

§ 1. ABOUT 150,000 species of insects are known in public and private museums; some with wings, others without; some are aquatic, others are aquatic only in the first stage of their existence; and many are parasitical.

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[1] The great division of the animal kingdom of the *Articulata*, to which insects belong, consists of the following four classes, the three first breathing by air-vessels (tracheæ) or air-pouches:—

1. *Insects.*—Head distinct; three divisions of the body, viz. head, thorax, and abdomen; three pairs of legs, and, in general, one or two pairs of wings.
2. *Myriapoda.*—Head distinct; 24 or more pairs of legs, no wings.
3. *Arachnida* or Spiders.—Four pairs of legs, head and thorax united, no antennæ or feelers, no wings.
4. *Crustacea*, as Crabs, Lobsters, &c.—Respiration by means of branchiæ or gills, and in general aquatic, five or seven pairs of legs.

Insects properly so called are divided into eight orders:—

1. Coleoptera or Beetles, &c., which have four wings, two hard or wing covers called Elytra, and two soft or membranous, used for flying, and folded under the elytra. Cantharides, the Egyptian Scarabæus, and the Ladybird belong to this family, which numbers upwards of 70,000 species.
2. Orthoptera, which have also four wings, but the wing-covers are like parchment; the larva, instead of resembling a grub as in the Coleoptera, only differs from the perfect insect by the want of wings; such are the locust, grasshopper, cricket, &c.

3. Neuroptera,

Naturalists have lately found blind insects of various gene
the great subterranean caves of Europe and America. Some
insects are carnivorous, others feed on vegetables; some of
carnivorous tribe live on dead, others on living animals, but
are not half so numerous as those that live on vegetables. S
change the kind of food as they grow from larva to perfect ins
in their first stage they eat animal food, and vegetables when
arrive at their perfect state.

Insects maintain the balance among the species of the vege
creation by preventing the tendency that plants have to encr
on one another. The stronger would extirpate the weaker, and
larger would destroy the smaller, were they not checked by in
which live on vegetables. On the other hand, many plants w
be extirpated by insects were these not devoured by other inse

Insects increase in number of species and variety of forms

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3. Neuroptera, with two pair of transparent or membranous wings,
soft, and in general elongated, as Dragon-flies, May-flies, Ant
&c.
4. Hymenoptera: 4 membranous wings; provided, besides jaws for g
ing or mastication, with a proboscis by means of which they
their nourishment; in many species of this order the female
sting. The hive bee, wasp, ichneumon fly, are examples of
order.
5. Lepidoptera, having four wings covered with minute scales or feat
whence their name; they derive their food by suction, by mean
proboscis, and their first state of development is that of a caterp
such are butterflies, sphinxes, moths, &c.
6. Hemiptera, in general four wings, but the upper pair are only in
apical parts membranous or transparent; hence their name,
signifies half-wing: some are entirely deprived of them, as the
mon bug; they have a kind of beak, instead of a proboscis, as i
three preceding families. The cicada, the wood-bug, common
&c., belong to the Hemiptera.
7. Rhipiptera, having a single pair of wings folding longitudinally
fan shape; only a few small genera constitute this family, the
known of which are Stylops and Xenos.
8. Diptera, with a single pair of wings, the mouth entirely adapte
suction, with a long retractile proboscis; the common fly and
are the best known species of this family.

Some entomologists have recently added two orders to the class of in
the Parasita and the Thysanura; the first live on the bodies of othe
mals; to one of its commonest genera belongs the human louse.

[1] Perhaps one of the greatest checks on the propagation of insect l
from insects themselves, many species depositing their eggs on the
of others, which in their development destroy the animal on which
have been deposited; that most destructive insect to the vine, the P
vitis, is a very remarkable instance of this, some dozen species of i
depositing their eggs on it in its incomplete state, thus keeping dow
number of one of the greatest plagues in wine-producing countries.

the poles to the equator: in a residence of 11 months in Melville Island, Sir Edward Parry found only six species, because lichens and mosses do not afford much nourishment for the insect tribes, though it is probable that every other kind of plant gives food and shelter to more than one species; it is even said that 40 different insects are quartered upon the common nettle. Beetles are probably an exception to the law of increase towards the equator, as they seem to be more numerous in species in the temperate regions of both hemispheres than in tropical countries. The location of insects depends upon that of the plants which yield their food; and, as almost each plant is peopled with inhabitants peculiar to itself, insects are distributed over the earth in the same manner as vegetables; the groups, consequently, are often confined within narrow limits, and it is extraordinary that, notwithstanding their powers of locomotion, they often remain within a particular compass, though the plants, and all other circumstances in their immediate vicinity, appear equally favourable for their habitation.

§ 2. The insects of northern Asia belong to a great extent to the same genera as those of Europe; those of the United States differ specifically from European species, though they often approach very near to the same forms. South America is as peculiar in its insect fauna as it is in its mammalia, and the tropical portion has a distinct set of forms from that of its southern extremity. The opposite, tropical zone of Africa differs widely in the same respect from South America, although not much inferior in the number and variety of its species and genera. In fact, under the same parallel of latitude, countries similar in soil, climate, and all other circumstances present the most striking differences in their insect tribes, even in those that live on animal substances.

Though insects are distributed in certain limited groups, yet most of the families have representatives in all the great regions of the globe, and some identical species are inhabitants of countries far from one another. The Pyrameis cardui, or "Painted Lady Butterfly," is found throughout the old world in North America and in Australia; and being a species which never could have been conveyed by man, its wide distribution must be due to its great powers of migration. The number of species of similar extended distribution is very limited, as species and genera here as in the larger animals are confined to definite areas. Being immensely more abundant and more definite in their specific characters, insects, as massed in large collections, afford clearer indications of the geographical limits of faunas and the biological character of countries than any other class of animals.

Mountain-chains are a complete barrier to insects, even more so than rivers: not only lofty mountains like the Andes divide the kinds, but they are even different on the two sides of the Col de Tende in the Alps. As with plants, they have the irarea of distribution and within the area their peculiar *station* or locality in which they are found. Thus each soil has kinds peculiar to itself, whether dry or moist, cultivated or wild, meadow or forest. Stagnant water and marshes have their separate species; some live in water, some run on its surface, and every water-plant affords food and shelter to many different kinds. Insects sometimes multiply suddenly to an enormous extent, and decrease as rapidly and as unaccountably.

Temperature, by its influence on vegetation, has an indirect effect on the insects that are to feed upon plants, and extremes of heat and cold have more influence on their localization than the mean annual temperature. Thus in the Polar regions the mosquito tribes are more numerous and more annoying than in temperate climates, because they pass their early stages of existence in water, which shelters them, and the short but hot summer is genial to their brief span of life.

In some instances height produces the same effect in the distribution of insect life as difference of latitude. The Parnassius Apollo, a butterfly native in the plains of Sweden, is also found in the Alps, the Pyrenees, and two or three closely allied species in the Himalaya. The Parnassius Smintheus, true to the habitat of the genus, is confined to the Rocky Mountains of North America. Some insects require several years to arrive at their full development; they lie buried in the ground in the form of grubs: the cockchafer takes three years to reach its perfect state, and some American species require a much longer time.

§ 3. Insects do not attain their perfect development till the plants they are to feed upon are in a state to afford them habitation and nourishment. Hence in cold and temperate climates their appearance is simultaneous with vegetation; and as the rainy and dry seasons within the tropics correspond to our winters and summers, insects appear there after the rains and vanish in the hot months; the rains, if too violent, destroy them; and in countries where that occurs there are two periods in the year in which they are most abundant—one before and one after the rains. It is also observed in Europe that insects decrease during the heat of summer and become more numerous in autumn: the heat is thought to throw some into a state of torpor, but the greater number perish.

When a plant is taken from one country to another in which it has no congeners, it is not attacked by the insects of the country: thus our cabbages and carrots in Cayenne are not injured by the insects of that country, and the tulip-tree and other magnolias are not molested by our insects; but if a plant has congeners in its new country, the insect inhabitants will generally soon find their way to the stranger.

§ 4. The common fly is one of the most universally distributed insects: it was unknown in some of the South Sea islands till it was carried there from Europe, where it has now become a real plague in many places.

Mosquitoes, gnats, or culices are spread over the world more generally than any other tribe of insects; they are the torment by night and by day of men and animals from the poles to the equator; the species are numerous and their location partial. In the arctic regions the Culex pipiens, which passes two-thirds of its existence in water, swarms during the summer in myriads: the lake Myvatn, in Iceland, takes its name from the legions of these tormentors that cover its surface. They are less numerous in central Europe, though one very small species of mosquito, the Simulium Columbaschense, appears in such clouds in parts of Hungary, especially in the Banat of Temeswar, that it is not possible to breathe without swallowing them in numbers: even cattle and children have been killed by them. In Lapland there is a plague of the same kind. Of all places on earth the banks of the Orinoco and of other great rivers of tropical America are the most infested by this plague. The account given by Humboldt is really fearful: at no season of the year, at no hour of the day or night, can rest be found; whole districts in the upper Orinoco are deserted on account of these insects. Different species succeed one another with such regularity, that the time of day or night may be known from their humming noise, and from the different sensations of pain which their several poisons produce. The only respite is the interval of a few minutes between the departure of one gang and the arrival of their successors, for the species do not mix. On some parts of the Orinoco the air is one dense cloud of poisonous insects to the height of 20 feet. It is singular that they do not infest rivers that have dark-coloured waters; each clear stream is peopled with its own particular kinds; though ravenous for blood, they would appear to be able to exist without it, as they are found in situations where no animals exist.

The tsetse-fly, peculiar to certain definite areas in South tropical Africa, is fatal to cattle; it is not found more to the north, but two very poisonous flies infest the forests of Western tropical Africa.

§ 5. The common honey-bee is the European insect most directly useful to man; it was introduced into North America not many years ago, and is now spread over the new continent, and is naturalized over Australia and New Zealand. Several species of the same genus are found in Southern Asia, but true honey-bees are unknown in South America and Australia, where their place is occupied by small stingless bees of an allied genus, producing inferior honey and wax.

Fire-flies are mostly tropical, yet there are four species in Europe; in South America there are many species, and so brilliant that their pale green light is seen at the distance of 200 paces: a Scolopendra, or Centipede, in Asia, is as luminous as the glowworm, and one in France is so occasionally.

The silkworm was originally introduced from China, from which country and from Northern India several allied species have been brought to Europe of late years with a view to utilising them in the production of silk. Some silkworms, as the Tusseh from Northern India, produces a coarser thread, adapted for inferior fabrics; the Yama-mai silkworm has been recently introduced into this country and into Prussia from Japan. The cochineal insect is a native of tropical America; there are many species of it in other countries; the Coccus lacca is Indian, the Coccus ilicis lives in Southern Europe, and there is one in Poland.

Scorpions under various forms are found in all warm climates; two or three species are peculiar to Europe, but they are small in comparison with those of tropical countries; one in Brazil is six inches long. As in the case of mosquitoes, the poison of the same species is more active in some situations than in others. At Cumana the sting of the scorpion is little feared, while that of the same species in Carthagena will produce, amongst other effects, loss of speech for many days.

Ants (*Formicidæ*, order *Hymenoptera*) of different kinds are universally distributed. Near great rivers they build their nests above the line of the annual inundations. The insects called white ants (*Termitidæ*, order *Orthoptera*), belonging to a different order, are so destructive to paper and clothing in South America, that Humboldt says there is not a manuscript in that country 100 years old.[1]

There are upwards of 1500 known species of spiders, and of their allied arachnidæ; each country has its own, varying in size, colour, and habits, from the huge bird-catching spider of South America to the almost invisible European gossamer floating in the air on its silvery thread. Many of this ferocious family are aquatic; and spiders, with some other insects, are said to be the first inhabitants of new islands.

§ 6. The migration of insects is one of the most curious circumstances relating to them: they sometimes appear in great flights in places where they never were seen before, and they continue their course with a perseverance that nothing can check. This has been observed in the migration of creeping insects: caterpillars have attempted to cross a stream. Countries near deserts are most exposed to the invasion of locusts, which deposit their eggs in the sand, and when the young are hatched by the sun's heat they emerge from the ground without wings, but as soon as they attain maturity they obey the impulse of the first wind, and fly, under the guidance of a leader, in a mass so dense that it forms a cloud in the air, and the sound of their wings is like the murmur of the distant sea. They take immense flights, crossing the Mozambique Channel from Africa to Madagascar, which is 120 miles broad: they come from Barbary to Italy, and a few have been seen to reach Scotland. Even the wandering tribes of locusts differ as to species in different deserts, following the universal law of organized nature. Insects not habitually migratory sometimes migrate in great numbers. In 1847, and again in 1869, lady-birds (or Coccinellæ) and the bean aphis arrived in immense numbers at Ramsgate and Margate from the continent in fine calm weather, and a mass of the Pyrameis cardui flew over a district in a column from 10 to 15 yards wide for two hours successively. Why these butterflies should simultaneously take wing in a flock is unaccountable; had it been for want of food they would probably have separated in quest of it. In 1847 the cabbage butterfly passed in clouds from the coast of France to England. Dragon-flies migrate in a similar manner.

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[1] At La Rochelle and some other parts of France a species of these destructive insects has become very abundant within a few years.

§ 7. Professor Ehrenberg discovered a new world of creatures in the Infusoria, so minute that they are invisible to the naked eye. He found them in fog, rain, and snow, in the ocean, in stagnant water, in animal and vegetable juices, in volcanic ashes and pumice, in opal, in the minute dust that sometimes falls on the ocean; and he detected 18 species 20 feet below the surface of the ground in peat-bog, which was full of microscopic live animals: they exist in ice, and are not killed by boiling water. While inquiring into the causes of the cholera which prevailed at Berlin in 1848, M. Ehrenberg discovered 400 species of living microscopic animalcules in different strata of the atmosphere, so that the air is analogous in the distribution of its inhabitants to the ocean, which has marine animals peculiar to different depths. These wonderful revelations have been since confirmed by various investigators, and more especially by the ingenious and exhaustive experiments and observations of M. Pasteur, who has demonstrated how difficult it is to exclude even the germs of life which everywhere abound in the atmosphere. This lowest order of animal life is much more abundant than any other, and new species are found every day. Examined by the microscope they seem to consist of a transparent vesicle, and some have a tail: they move with great rapidity, and show a certain instinct by avoiding obstacles in their course; others have silicious shells. Language, and even imagination, fails in the attempt to describe the inconceivable myriads of these invisible inhabitants of the air and the earth; they have been brought up alive from enormous depths at sea, and vast plains of the ocean bed consist of their remains.

CHAPTER XXXI.

DISTRIBUTION OF FISHES, MOLLUSCA, INFUSORIA, AND MARINE MAMMALIA.

§ 1. Character of the marine fauna; its distribution over the globe in nine homozoic belts. § 2. Description and classification of Fishes. § 3. The Arctic belt; the Boreal belt; the Celtic belt; limit of the salmon; the Spanish belt. § 4. Species of European fishes. § 5. The Pacific belt; effect of currents on the distribution of fishes. § 6. Fresh-water fishes; analogies between the inhabitants of the sea and land; electric and luminous fishes. § 7. Shell-fish, mollusca, &c.; various zones of depth in the ocean; five zones in the Celtic belt; five zones of the Mediterranean. § 8. Fauna of the tropical Atlantic; the Indo-Pacific region. § 9. Marine life of extratropical southern latitudes; discoveries from deep-sea soundings. § 10. Quantities of animalculæ in the ocean; cause of particular colours in some seas; prodigality of ocean animal life a compensation for deficiency of vegetation. § 11. Marine mammalia.

§ 1. THE marine fauna depends upon the heat and light of the sun, therefore it is rich in infinitely varied forms of being and brilliancy of colouring between the tropics, both of which gradually diminish in exuberance to the polar oceans, where the colouring is dull, the number of species few, but the individuals of each species exceedingly abundant. The marine fauna varies also with the depth, decreasing in number and variety of species from the surface downwards, where the water is colder, so that each depth has a corresponding latitude of the same temperature in which the species are either the same or representative. This is analogous to what is observed on land, where the temperature of the air decreases with the height above the surface of the sea, while in the ocean the temperature of the water decreases with the depth below it.

The fauna of the ocean consists of Marine Mammalia, Fishes, Mollusca, Annulosa, Zoophytes, and Corallines. These are distributed in nine belts which surround the globe, each of which, being under nearly the same circumstances as to climate, has in its different parts either the same or representative species, and therefore it is said to be Homozoic.[1] The intertropical ocean forms the central homozoic belt; it has four others on each side, of which those at equal distances N. and S. have faunas mutually representative; the two last belts are the circumpolar oceans. The lines which bound the homozoic belts are climatal, and nearly correspond with the isothermal lines on land, so they are neither parallel to one another, nor do they coincide with the parallels of latitude, but are undulating from the effect of the warm and cold currents which come from the tropical and polar oceans. The fauna of a great part of the southern oceans is as yet very imperfectly known; that of the north Pacific, and especially of the north Atlantic, have been carefully studied, both as to extension and depth.

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[1] K. Johnston's Physical Atlas, 2nd edition.

§ 2. Fishes, properly so called, advance in the water by means of their flexible bodies and tail; the upper fins serve to balance them, and the lower ones assist them in turning, and also enable them to move slowly and to maintain themselves suspended and steady in a strong current. When in rapid motion their fins are folded close to the body in order to offer no resistance to the water. In flat-fish, however, and all those that are broad horizontally, the fins aid considerably in their progressive motion. Most fishes are provided with an air vessel, or swimming-bladder, which they can compress or expand when they wish to sink down or rise to the surface, but it is nearly wanting or rudimentary in such species as live at the bottom of the sea and rarely or never come to the surface. It is altogether wanting in the Remora, which has an apparatus for attaching itself to other fishes, chiefly different species of shark, and is carried about by them. The senses of seeing, hearing, and smelling are very acute in fishes, and most that live in deep water have very large eyes in order to collect and concentrate the small portion of light that can penetrate so far.[1]

§ 3. The Arctic Ocean is the first of the great zones into which it is convenient to class the distribution of marine animals. Its southern boundary is mainly determined by the direction and flow of cold currents. Its greatest breadth is between the pole and the Gulf of St. Lawrence, and includes the Banks of Newfoundland, while its least extension is between the pole and the extreme north of Scandinavia. The genera are not very numerous in this great ocean. But the most remarkable feature of this belt is the enormous shoals of the genus Gadus or cod that crowd the banks of Newfoundland. The cold current from the east coast of Greenland, which unites with that from Davis Strait and runs along the American coast inside the Gulf-stream, is the highway by which these myriads of cod annually arrive. The quantity is so great that as many as half a million have been taken in a week by one vessel.

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[1] The skeletons of fishes are composed either of bone or cartilage, hence Cuvier's division of the finny tribe into osseous or bony, and cartilaginous fishes. The fins are formed of spines or rays of bone united more or less by a thin web or membrane; some are hard and others soft; the bony fishes are subdivided into hard-finned or *Acanthopterygians*, as the perch, mullet, mackerel, &c., and the soft-finned or *Malacopterygians*, as the salmon, herring, pike, carp, cod, flat-fishes, eels, &c. The cartilaginous fishes, or *Chondropterygians*, include the genera of the sturgeons, sharks, skates, lamprey, sun-fish, diodons, &c.

The second Homozoic or Boreal belt extends along the whole of the Norwegian coast, includes nearly all Iceland, and on the American side it stretches along the coast of Maine to Cape Cod, in Massachusetts. It is owing to the cold arctic current, which is of a much lower temperature than the ocean, and several degrees below that of the Gulf-stream, that the markets of all the maritime towns of the United States, from Maine to Florida, are supplied with such a variety and abundance of excellent fish, while those in the Gulf-stream are very inferior on account of its warmth, for as a general rule the best fish for the table live in cold water.

The Celtic belt stretches along the Virginian coast on the west; it includes the seas round the British islands, from Shetland to the northern parts of the Bay of Biscay, as well as the North Sea and the Baltic. The British islands lie between two great provinces of fishes, one on the south, the other on the north, from each of which we have occasional visitors. The tunny, torpedo, pilot fishes, and various species of sharks, come at times from our southern neighbour, and some years ago a great number of the tropical Bonito and Albicore arrived by the Gulf-stream, off the coasts of Cornwall and Devonshire, committing great devastations among the shoals of pilchards. In the month of February enormous quantities of cod arrive from the north, along the coast of Norway; the shoals are often many yards deep, and so closely crowded together, that the sounding lead can hardly pass between them; 16,000,000 have been caught in one place in a few weeks. These shoals are on their way to the Dogger Bank, a rich fishing-ground in the North Sea, from whence the markets of England and northern France are supplied with a great variety of excellent fish. But the group of fish peculiarly British has its centre in the Irish Sea; it is however mixed with others from the seas bounding the western shores of Central Europe, which form a distinct group. Herring fisheries are characteristic of the British seas. They come in winter and are extremely capricious, frequenting a place in enormous quantities for a few years, and then forsaking it and going somewhere else: this was particularly the case in the Firth of Forth in the early part of the present century; however, they are always exceedingly abundant in the seas that surround Ireland and Scotland.[1] The

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[1] Recent investigations go far to prove that the herring is not migratory,

Bay of Dublin is celebrated for its haddocks—a fish found everywhere in our seas; and great shoals of pilchards and mackerel visit the Devonshire and Cornish coasts at different seasons of the year, being among the number of gregarious and migrating fishes. Wherever the sea-bed is of sand or mud round our coasts, there turbot, soles, and other flat-fish abound.

The common salmon does not exist south of the 45th parallel of north latitude on the east coast of America, and it is probably confined within similar limits on the eastern coast of Asia. It is said to be an inhabitant of all the northern parts of the Old World, from the entrance of the Bay of Biscay to North Cape, and along the arctic shores of Asia and Kamtchatka to the sea of Okhotsk, including the Baltic, White Sea, Gulf of Kara, and other inlets. Other species of the salmon tribe are plentiful in the estuaries of the rivers in Kamtchatka and on the opposite coast of America as far south as Oregon, but they do not appear to extend to China. These delicious fish are found in vast numbers in the rapid streams of British Columbia and Vancouver Island, and in the season they afford the chief sustenance to the Indians of those countries. Salmon is so far a sea-fish that it only goes up rivers to spawn, and if by chance it is prevented from returning to the sea it becomes sickly. They make extraordinary leaps over impediments of rocks and walls in order to reach a suitable place to deposit their eggs. It is entirely a cold-water fish, and the new plan of depositing its spawn in rivers which salmon have not hitherto frequented will probably succeed if these rivers empty themselves into a cool sea; but if they flow into a warm one, the fish may live, but will be very indifferent for the table.

In the three preceding belts of marine life the species have been the same on both sides of the Atlantic, but that is no longer the case south of the 44th parallel of north latitude, partly on account of the depth of that ocean and also from the absence of islands. The Lusitanian or Spanish belt embraces the Bay of Biscay, the seas on the west coasts of Spain and Africa, so far as the Azores, and extends west to the Canaries. Pilchards abound in the Bay of Biscay, and in other places there are numerous species of mullet near the mouths of rivers; in general the fauna is similar to that in the Mediterranean.

§ 4. The late Prince Charles Lucien Bonaparte has shown that there are 853 species of European fish, of which 210 live in fresh

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but remains mostly at the bottom of the sea during certain months, and comes to the surface at the spawning season. In evidence of this, herrings are now taken at all times of the year on the coast of Caithness, and in the Firth of Forth.

water, 643 are marine, and 60 of the latter go up rivers to spawn: 444 of the marine species inhabit the Mediterranean, 216 are found off the British coasts, and 171 are peculiar to the Scandinavian seas; so that the Mediterranean is richest in variety of species. In it there are several peculiar sharks, the sword-fish, dolphins, anchovies, and numerous species of the scomber or mackerel tribe; one of the largest of which, indeed of all edible fish, is the tunny, for which fisheries of great commercial importance are established on the southern coasts of France, in Sardinia, Elba, the Strait of Messina, and the Adriatic. Numerous species of skate or ray are particularly characteristic of this sea, especially the torpedos, which have the power of producing a galvanic shock, and even emitting under certain circumstances an electric spark.

The Mediterranean furnishes only two or three American species, a few in common with the Red Sea, and a smaller number still seem to be Indian. Some of these species had probably entered the Mediterranean before it was separated from the Red Sea by the Isthmus of Suez, for geological changes have had very great influence on the distribution of fishes everywhere. Although the communication with the Black Sea is so direct, there are only 27 common to it and the Mediterranean, no doubt on account of difference of temperature in the water. The Black Sea forms a district by itself, having its own peculiar ichthyology; and the fishes of the Caspian Sea differ entirely from those in every other part of the globe. Madeira, insulated amid a great expanse of ocean, has many peculiar species; they amount in number to half of those in Britain, and nearly as many are common to Britain and Madeira as to that island and the Mediterranean, so that many of our fish have a wide range in the Atlantic. The temperature of the Mediterranean is too high to furnish good fish for the table; the best are indifferent when compared with those of our more northern latitudes.

§ 5. Dr. Richardson has found that there is one great homozoic belt in the Pacific, extending 42° on each side of the equator, between the meridians including Australia, New Zealand and the Malay Archipelago, China, and Japan, in which the genera are the same; but at its extremities the arctic and antarctic genera are mingled with the tropical forms. Many species, however, which abound in the Indian Ocean, range as far N. as Japan, which no doubt travel by the Japanese current which sets in that direction. The middle portion of this belt is vastly extended in longitude, for very many species of the Red Sea, the eastern coast of Africa, and the Mauritius, range to the Indian and China seas, to those of North Australia, and through all the Polynesian waters; in this immense belt, which embraces three-fourths of the circumference of the globe and 60 degrees of latitude, the fish are very nearly ali continuous chains of islands in the Pacific being favourable t dispersion. They are remarkable for extreme beauty of col which they owe to the light and heat of a tropical sun, account of the high temperature of the water they are of littl as objects of food. In the North Pacific the generic form from those in the Atlantic, and, as in that ocean, they incr numbers and variety with the latitude. From the near ap of the American and Asiatic coasts at Behring Strait, the both sides are nearly alike down to the sea of Okhotsk on on and to Admiralty Inlet on the other. The sea of Japan a neighbouring coasts of China are frequented by fishes l northern forms, which are there said to mingle with many common to the temperate and warm parts of the ocean, a ci stance entirely dependent on the submarine currents. The fi on the coasts of China and Japan rival those on the banks of foundland, for in both cases cold currents run close along coasts from the N., by which the fish arrive from the high tudes, while the counter-current from the Pacific Drift brin inhabitants of a warmer sea; but although these currents juxta-position, it may be doubted whether the species ac mingle, on account of the difference in temperature of th streams.

In the South Pacific Humboldt's current brings a quan excellent fish along the coasts of Chile and Peru, even as the equator. Species representative of the cod and genus generally reappear in the southern seas very like those northern, and the sharks of the China seas are for the mo identical with those of Australia; the cartilaginous fish to the latter belong have a much wider range than most of the o however, five genera peculiar to the seas of very high so latitudes range throughout the whole circle of the Antarctic

No doubt currents are the highways of the ocean by warm-water fish may travel to high latitudes, and cold- species to low, without much change of temperature; bu tropical ocean would be a sea of fire to polar fish, and yet tw remarkable Greenland genera,[1] which inhabit such deep wate they are seldom met with except when thrown up by a have been discovered on the coasts of New Zealand and Australia. Had these fish passed the tropics they must descended to a depth of 2000 fathoms before they came to a perature that they could probably endure. If so, marine cre must be able to sustain the enormous pressure of 12,000 ft. of water, which the late deep-sea soundings show that they do.

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[1] Notocanthus and Macrourus.

§ 6. With regard to fresh-water fishes, most great systems of lakes have their peculiar species, as the lake of Baikal; and the fishes of the great inter-alpine lake of Titicaca, which amount to seven or eight, belong to genera only found in the higher regions of the Andes. In the North American lakes there is a bony-scaled fish, bearing some analogy to those of the Secondary geological epoch; there are four species of perch peculiar to the North American waters, but of all the species, one only, the pike, is absolutely identical with those of our European lakes and rivers; the Gillaroo trout, which is remarkable for having a highly muscular stomach, which has been compared to a bird's gizzard, is found in a few lakes of northern Ireland only. The fresh-water fish of northern climates are most esteemed for the table.

Each tropical river has its peculiar species. The fresh-water fish of China[1] resemble those of India in their generic forms, but not in species, and those of the Cape of Good Hope and South America differ from those of India and China. Sea-fish, in immense quantities, frequent the estuaries of rivers everywhere; the mouth of the Mississippi swarms with them, and the quantity at the mouth of the Don in the Sea of Azof is prodigious.

There are singular analogies between the inhabitants of the sea and land. Many of the medusæ, two corallines, the Physalia or Portuguese man-of-war of sailors, sting like a nettle when touched. A cuttle-fish at the Cape de Verd Islands, changes colour like the chameleon, assuming the tint of the bottom on which it rests, as do some of our fresh-water fishes. Herrings, pilchards, and many other aquatic animals, are luminous. The medusæ, or sea-nettle tribe, which are numerous in species, have also the faculty of emitting light. In warm climates, especially, the sea seems to be on fire, and the wake of a ship is like a vivid flame with the all but microscopic Noctilucæ. These luminous creatures are the glow-worms and fire-flies of the ocean, while the fish with great eyes that live in its dark abyss represent its bats and owls. But among terrestrial animals there is nothing analogous to the property of the Gymnotus electricus of certain South American lakes, or of the Silurus electricus of the African rivers, and the several species of torpedo of the Mediterranean, which possess the faculty of giving an electric shock by means of a very beautiful organic voltaic apparatus with which they are provided.

§ 7. Besides these more active inhabitants of the deep, the ocean is the abode of myriads of living creatures: shell-fish or mollusca, crustacea, star-fish, sea-urchins, madrepores, corallines, &c. &c., of innumerable families and species, characteristic of the different depths and homozoic belts, all of which strictly follow the law of partial dispersion; some have very wide areas of habitation, and a few genera are nearly cosmopolite.

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[1] The Chinese fresh-water fish are Cyprinidæ, Ophicephali, and Siluridæ.

Throughout the whole ocean the littoral, or first zone of depth, is the space included between the high-water mark and the low; hence it is exceedingly variable; in some places, as in the Mediterranean, it is not more than a foot or two deep, while in the Bay of Fundy it is 60, and in the British Channel 30 ft. On every littoral zone some species of the genera Purpura, and Littorina or Turbo, are to be met with, except in the South African and South Australian.

From the surface to more than 100 fathoms in the arctic and boreal belts there are five distinct zones of depth. The first or littoral zone, which extends to a depth of 15 fathoms, is distinguished by the genera Littorina or Turbo, the Purpura or whelk, and the Patella or limpet; the other four contain various kinds of mollusca, star-fish, sea-urchins, sponges, corallines, and sea-weeds. The most remarkable of these is an arborescent star-fish which inhabits the depths of the North Atlantic, and the Comatula Europæa, belonging to the stone-lily family, or crinoids, which are fixed to the rocks when young, but become detached when full-grown; they are numerous in the arctic seas to the W. of Spitzbergen; one is met with in the Indo-Pacific Ocean, and a species has been found in Dublin Bay. They are the last representatives of those beautiful zoophytes which characterised the oolitic period. The larger crustacea are exceedingly numerous in this belt, especially on the rocky coasts and islands of Norway, where an extensive fishery supplies the English, Dutch, and French markets with crabs and lobsters.

The Celtic belt, which includes the British seas, has five zones of depth, each of which has its particular inhabitants, consisting of shell-fish, crustacea, corallines, and other marine animals. The first zone, lying between high and low water mark, is shallow in some places and 30 ft. deep in others. In all parts of the northern hemisphere it presents the same phenomena: but the animals vary with the nature of the coast, according as it is of rock, gravel, sand, or mud. In the British seas the animals of this littoral or coast zone are distributed in three groups that differ in a marked manner from one another, though many, as the whelk and turbo, are common to all. One occupies the seas on the southern shores of our islands and both Channels; a middle group has its centre in the Irish seas and the adjacent coasts of England and Ireland. The second zone extends from the low-water mark to a depth of from 7 to 15 fathoms below it, and is crowded with animals living on and among the sea-weeds, as mollusca, star-fish, sea-urchins, and many zoophytes. In the third zone, which is below that of vegetable life, marine animals are more numerous and of greater variety. It is particularly distinguished by animals that by their union assume an arborescent form, and seem to take the place of plants—carnivorous mollusca, together with large species of radiata. It ranges from the depth of 15 to 50 fathoms. The fourth zone is the region of more massive corals, peculiar mollusca, and zoophytes that only inhabit deep water. This zone extends to 100 fathoms, below which there are only two kinds of shell-fish and an annelid, or sea-worm, but it is probable there are more if the sea were carefully sounded. Oysters abound in these seas, as well as the mussel, cockle, and periwinkle. The E. coast of America, which has few shells, has in this belt several of those which we find on the coasts of Europe, the rest are representative. This Celtic belt has received colonists from the Atlantic on one side, and from the boreal and even the arctic on the other. Those from the two latter are regarded as descendants of members of the fauna of this area as it existed before the glacial period. The number of animals in the Celtic zone is very great.

In the Mediterranean generally there are five zones of depth, of which the first is a mere narrow strip along the coasts, in which the creatures differ according as it is rocky or sandy; but the nearly cosmopolite genera of purpura and littorina are found here also. The second zone, which descends to 15 fathoms, abounds in cuttle-fish, and has some very peculiar species of Echini. The third zone is the region of sponges, which form an object of commerce, together with various corallines and peculiar shells. The most remarkable production of the fourth zone, which descends to 100 fathoms, is the red coral used for ornaments; it is obtained at considerable depths off the coast of Sicily and Sardinia, but chiefly off the N. coast of Africa, between Tunis and Algiers, and in the Grecian Archipelago. All abound in living creatures, for this sea is extremely rich and varied in its inhabitants. The observations of the late Professor E. Forbes in the Egæan Sea were particularly interesting. He found that from the surface to the depth of 230 fathoms there are eight distinct zones, each of which has its particular vegetation and inhabitants. The number of mollusks and other marine animals is greater specifically and individually between the surface and the depth of two fathoms than in all the seven regions lower down taken together, and both decrease downwards to the depth of 105 fathoms; between which and the depth of 230 only eight species of shells were found; animal life ceases in that part of the Mediterranean at 300 fathoms, but it has been already stated that recent and more accurate investigations of the deep sea have revealed the existence of animal life at the greatest depths. The changes from zone to zone are not abrupt; some of the species of an inferior region always appear before those of the region above vanish; and although there are a few species the same in some of the eight zones, only two are common to all the eight.

§ 8. All circumstances combine to produce a rich marine fauna on the western side of the tropical Atlantic. The Caribbean province is the only part of that ocean in which a region of coral reefs exists; besides, it is inhabited by mollusca, articulata, and radiata, strikingly representative of the forms, but entirely different in species from those in the Indo-Pacific. The difference between the Caribbean assemblage of marine life and that in the Gulf of Mexico on the one hand, and along the extensive shores of Brazil on the other, appears chiefly to arise from the nature of the bottom of the sea. The number of species that range from Florida to Rio Janeiro is very great.

In the Indo-Pacific region the inhabitants of the several zones of depth are not yet well known, but different species of the Purpura and Littorina still succeed each other along the western coasts of the American continent; and although species of these two genera still prevail, there is a similar representative succession of species of the beautiful Haliotis, or Sea Ear, from Tasmania to Behring Strait. This noble ocean is the very realm of reef-building corals; they fill it from tropic to tropic, with the exception of an area W. from the coasts of Central America, and another between North Australia and the shores of India and China. In these calm and limpid waters the madrepores and branching corals are covered with living creatures of the most varied forms and of every colour, either hanging on them like leaves and flowers, or clinging to them like mosses and lichens, while the clear sand below is covered with the singular forms and tints of the Echinodermata, or variegated like a bed of ranunculuses with the sea anemones. In these living groves brilliant green contrasts with brown, bright red, golden yellow, and purple of every shade, from the ruddy to the purest azure. The brilliant rosy, yellow, or peach-coloured nullipores overgrow the decaying masses, and are themselves interwoven with the pearl-coloured plates of the retipores, resembling the most delicate ivory carvings, while close by wave the trellis-like lilac and yellow fans of the gorgonias, the milk-white bells of the jelly-fish float softly in the clear water, and the little fish sparkling with every gay metallic hue dart through the whole in chase of their prey. When the shades of evening fall the sea shines like the Milky-way with myriads of brilliant sparks; the microscopic medusæ and crustaceans invisible by day form the beauty of the night; and the sea-feather, vermilion in daylight, now waves in a green phosphorescent light; every part of it is luminous; even those which are dull brown now become radiant in the most wonderful play of green, yellow, and red light; and the sun-fish[1] with its silver disc six feet broad moves slightly luminous among these lesser fires.[2] The nautilus and harp are among the most beautiful of the tropical shells,—the pearl oyster (*Meleagrina Margaritifera*) one of the most celebrated; it abounds throughout the Persian Gulf, and on the coasts of Borneo and Ceylon, and produces the finest pearls. There are other pearl-bearing shells in the Pacific, especially in the Bay of Panama, and of an inferior description in the Caribbean Sea. Some shell-fish are exceedingly limited in their distribution, as the Haliotis gigantea, which is peculiar to the seas S. of Australia and the shores of Tasmania. The E. and W. coasts of intertropical Africa have a totally dissimilar fauna, and the E. and W. coasts of tropical America have only one molluscous animal in common, and both differ from those in the islands of the Pacific and the Galapagos Archipelago, which last forms a distinct region. Notwithstanding the many definite marine provinces, the same species are occasionally found in regions widely separated. A few of the shells of the Galapagos Archipelago are analogous with those of the Philippine Islands; the Cypræa moneta lives in the Mediterranean, the seas of South Africa, the Mauritius, the East Indies, China, and the South Pacific, even as far as Tahiti, and the Janthina fragilis, the animal of which is of a beautiful violet colour, floats on the surface in every tropical and temperate sea. The mollusks have a greater power of locomotion than is generally supposed. Some migrate in their state of larva, being furnished with lobes which enable them to swim freely. The larva of the common scallop is capable of migrating to distant seas, the argonauta and nautilus float or swim along the surface.

§ 9. Before Sir James Ross's memorable voyage to the Antarctic seas, the profound and dark abysses of the ocean were supposed to be entirely destitute of animal life, now it has been proved that no part of it is uninhabited. For although the silicious microscopic shells brought up from the depths of 1000 fathoms in Erebus Bay have proved to be the exuviæ of plants and not of a shell-fish, the discovery led to an investigation of the sea-bed in both of the great oceans. During the soundings across the North Atlantic for the electric telegraph cable in 1857, the mud that was brought up from the bottom, at a depth of more than three miles, was found to be in a great measure formed of microscopic calcareous shells; scarcely a grain of sand was among them; the bottom of the Gulf of Mexico and of the Gulf-stream is everywhere a mass of microscopic shells of the most delicate structure, and in a state of complete preservation, which shows that the sea is calmly tranquil at these depths. But the bottom of the ocean is now known by deep-sea soundings to be the abode of the living as well as the vast sepulchre of the dead. In sounding to ascertain the nature of the base of the North Atlantic for laying telegraphic lines, Dr. Wallich, naturalist to the expedition, found, at a depth of about a mile and a half midway between the N. of Ireland and Greenland, that 95 per cent. of the matter of the ocean-bed consists of living foraminifera of the group Globigerina. Mixed with these was a vast quantity of most minute bodies called Coccolites, both singly, and attached at regular distances on cell-like bodies; both are transparent and colourless, and imbedded in gelatinous matter. Bodies identical with these are found to constitute the bulk of the material of which the vast chalk deposits are formed, and Professor Huxley has discovered in the ooze brought up from the greatest depths of the Atlantic and Indian oceans a film of living organic substance to which he has given the name of Bathybius, and which has been termed Protoplasm, the lowest form of life. Two worms or annelids were also discovered at these great depths: one that coats itself with a tube of the shells of young Globigerinæ nicely cemented together; in the other the tube is lined with a tough substançe of a rich sienna colour. These seem to perforate the shells of the Globigerinæ, and, could they bore through gutta percha, it would be vain to lay a telegraphic line; but happily it is impervious to annelids unless they can secrete a chemical solvent: thus it is important to ascertain whether these marine insects are capable of ruining the noblest work of man.[1] The deep-sea soundings made in the summer of 1869, in the *Porcupine*, by Dr. Carpenter, Professor Wyville Thomson, and Mr. Gwyn Jeffreys, have finally settled the question of the existence of living animals at great depths in the ocean. At 2,435 fathoms in the Atlantic, species of Crinoids, Echinoderms, Mollusca, and Crustacea were found in a temperature of 36·5° of Fahrenheit.

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[1] The Orthagoriscus mola.

[2] Schleiden's Lectures.

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§ 10. The quantity of minute animal life in the ocean exceeds all imagination. The discoloured portions of the seas generally owe their tints to myriads of minute animalcula. Dr. Poeppig mentions a stratum of red water, near Cape Pilares, 24 miles long and 7 broad, which, seen from the mast-head, appeared of a dark-red colour; on entering it became of a brilliant purple, while the water in the wake of the vessel was of a rosy hue. The water itself was perfectly transparent, but small red masses could be discerned moving in spiral lines. The colour of the Vermilion Sea off the coast of California is no doubt owing to a similar cause; Mr. Darwin found red and chocolate-coloured water, which had been before observed by Ulloa on the coast of Chile, over spaces of several square miles, full of microscopic animalcula, darting about in every direction, and sometimes appearing to explode. Professor Dana mentions, in his memoir on the Distribution of the Crustacea, having sailed through an extensive area of "bloody water" off the coast of Chile, which owed its colour to myriads of minute crustacea: he met with another instance of the same in the tropical Atlantic.

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[1] Dr. Wallich's Memoirs in the 'Magazine of Natural History.'

These minute forms of organic life, invisible to the naked eye, are extensively distributed throughout the ocean; the small points which shine at night are sometimes so numerous that they give a milky colour to the sea by day, but several varieties of infinitesimal creatures are intensely and extensively developed in both the polar oceans, and serve for food to the higher orders of fishes in latitudes beyond the limits of the larger vegetation, though they themselves probably live on the microscopic plant already mentioned, which abounds in all seas. In the Arctic Ocean, where the water is of a pure transparent ultramarine colour, areas of 20 or 30 square miles, and 1500 feet deep, are green and turbid from the quantity of minute animalcula.

The enormous prodigality of animal life supplies the place of vegetation, so scanty in the ocean in comparison with that which clothes the land; still it probably would be insufficient for the supply of the marine creation were the deficiency not made up by the superabundant land vegetation and insects carried to the sea by rivers. The fish that live on seaweed must bear a smaller proportion to those that are predaceous than the herbivorous animals on land do to the carnivorous. Fish are certainly most voracious; none are without their enemies; they prey, and are preyed upon; and there are species which even devour the live coral, hard as its coating is; nor does the coat of mail of the Mollusca and Crustacea protect them. Whatever the proportions may be which predatory fish bear to herbivorous, the quantity of both must be enormous, for, besides the infusoria, the great forests of fuci and seaweed are everywhere a mass of infinitely varied forms of animal life, either parasitical, feeding on them, seeking shelter among them, or in pursuit of others.

§ 11. The polar seas are the habitations of the hugest and the most minute of the creatures whose dwelling is in the deep. They are the home of the marine mammalia, the largest of living creatures, which, as their name implies, suckle their young. While fish breathe by gills which separate the air dissolved in the water from it, the marine mammalia are furnished with lungs and respire like terrestrial quadrupeds, so that they are obliged to come to the surface from time to time to inhale the air. They form two distinct families, Phocæ or seals, and Cetacea or whales.[1]

Seven species of the seal tribe live in the Arctic Ocean and the North Atlantic, but the Greenland seal, the bearded or great seal, and the Phoca leporina, are also found in the high latitudes of the North Pacific. Seals live exclusively on fish, and are seldom found at a great distance from land or ice islands; their favourite haunts are the polar oceans and desert islands in high latitudes, where they bask in hundreds on the sunny shores during the brief summer of these inhospitable regions, and become an easy prey to man, who has nearly extirpated the race in many places; 1,000,000 are killed annually in the South Atlantic alone. The common Greenland seal is six or seven feet long, with a face like that of a dog, and a large intelligent eye. It is easily tamed, and in the Orkney Islands it is so much domesticated that it follows its master, and helps him to catch fish. This seal migrates in herds twice in the year, and returns again to its former haunts. They come to the coasts of Northern Europe and the British Islands at the time of their migrations, but it may be considered a constant inhabitant of our northern shores. The walrus, a grim-looking creature, with tusks two feet long, bent downwards, and its nose covered with strong transparent bristles, has a body like that of a seal, 20 feet long, with a coat of short gray or yellow hair. It sleeps on the floating ice, feeds on seaweed and marine animals, and lives chiefly in the Arctic Seas, but sometimes is met with in Behring Strait, the coasts of Magdalen Island, and very rarely in the Gulf of St. Lawrence. Large herds of seals reach the coasts of Labrador on the fields of ice borne by the currents from Davis Strait, and there they fall a prey to the fishermen who watch for the annual arrival of these "sea-meadows." It is computed that upwards of 1,000,000 are killed every year in the northern hemisphere.

Seals abound in the Antarctic seas and the high southern latitudes. Sir James Ross found some of the islands in the Antarctic

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[1] The Phocæ consist of seals properly so called, without external ears, inhabiting our Northern seas; of Otariæ, or eared seals, chiefly confined to the Antarctic latitudes; and of the anomalous Trichecus, or Walrus. The Cetacea are subdivided into the Manatus and Dugong, which are herbivorous and live within the tropics; all the rest are predaceous, namely, Dolphins or Porpoises, the Cachalot or Spermaceti Whale, and the Whalebone Whales, or Balænidæ, to which belong the Greenland or Right Whale, the Rorquals, &c. It is no doubt contrary to all zoological rule to place mammalia among fishes, but the object of this chapter is rather to convey some idea of the inhabitants of the ocean than to follow their scientific affinities.

Ocean overrun by the Phoca elephantina, or the sea-elephant. The fur species, Arctocephalus ursinus, was also very numerous, chiefly about the Falkland Islands. At one time it frequented the southern coasts of Australia in great numbers, but this and other species have now become scarce, from the indiscriminate slaughter of old and young.

The marine cetacea consist of three groups—dolphins or porpoises;[1] the spermaceti whales, or Physeters, which live on fish, and are provided with long jaws and numerous teeth in the lower one; and whales, properly so called, which have no teeth, but are furnished with whalebone inserted in the upper jaw, the extreme filaments of which act as a kind of net to catch the small marine animals which form their principal food. The cetacea breathe by an opening in the centre of the head, called by whalers the blower, corresponding to the nose of terrestrial mammalia, and which also serves to expel the water taken into the mouth with the food, in the form of jets, which vary in height and form according to the species.

The most singular and beautiful of the dolphin tribe is the Narwhal or sea-unicorn (*Monodon monoceros*), which has a tusk of fine ivory, wreathed with spiral grooves, extending eight or 10 feet straight from the head; in general there is only one tusk, but there are always the rudiments of another, and occasionally both grow to an equal length. The old narwhals are white, with blackish spots; the young are of an uniform dark colour. This singular creature, which is about 16 feet long, swims with great swiftness. Dr. Scoresby has seen 15 or 20 at a time playing round his ship in the Arctic seas, and crossing their long tusks in all directions, as if they were fencing. They live among the fields of ice between the N. parallels of 70° and 80°, in Davis Strait, Disco Bay, and the gulfs and creeks of Greenland. Some wander as far S. as Scotland and the northern coasts of Europe, but very rarely.

The spermaceti whale, Cachalot, or Physeter, belonging to the tribe of the predaceous spouters, is one of the most formidable inhabitants of the deep. Its average size is 60 feet long and 40 feet in circumference; its head, equal to a third of its length, is extremely thick and blunt in front, with a throat wide enough to swallow a man. The proportionally small swimming paws, or pectoral fins, are at a short distance behind the head; and the tail, which is in the form of a triangle six or seven feet long and often

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[1] The carnivorous cetacea, with a few remarkable exceptions—the Inia Geoffroyi and others of the upper Amazon and its tributaries, and the Platanista Gangetica of the Ganges—inhabit the ocean. The dolphin seen in the rivers of inner Africa is probably a Lamantin or Manatus.

20 broad, with a notch between the flukes, is its chief organ of progressive motion and defence. It has a hump of fat on its back, is of a dark colour, but with a very smooth skin. These sperm-whales have two nasal apertures or blowers on the top of their head, through which they throw at each expiration a succession of jets like smoke at intervals of 15 or 20 minutes, after which they toss their tails high in the air and go down head foremost to vast depths, where they remain for a considerable time, and then return again to the surface to breathe. The jet or spout is from six to eight feet high, and consists of water mixed with air expired from the lungs. This whale contains sperm-oil and spermaceti in every part of its body; the latter substance, however, is chiefly in a great reservoir in its head which makes it very buoyant: ambergris is sometimes found in the inside of the body; it is an intestinal concretion, with usually the beaks of cuttle-fish for a nucleus. These huge monsters, occasionally 75 feet long, go in great herds or schools of 500 or 600. Females with their young and two or three males generally form one company and the young males another, while the old males feed and hunt singly. The sperm-whales swim gracefully and equably with the upper part of the head above water; but when a troop of them play on the surface, some of these uncouth and gigantic creatures leap with the agility of a salmon several feet into the air, and fall down again heavily with a tremendous crash and noise like a cannon, driving the water up in lofty columns capped with foam. The fishery of this whale is attended with danger: not only the wounded animal, but its companions who come to its aid, sometimes fight desperately, killing the whalers and tossing them into the air with a sweep of their tremendous tails, or biting a boat in two. In 1820 the American whaler 'Essex' was wrecked in the Pacific by a sperm-whale: it first gave the ship so violent a blow that it broke off part of the keel; then, retreating to a distance, it rushed furiously and with its enormous head beat in a portion of the sides; and the crew had just time to save themselves in the boat when the vessel filled. They often lie and listen when suspicious of mischief. No part of the aqueous globe is free from their visits; though chiefly the inhabitants of southern latitudes, they are found at the Aleutian Islands in the Pacific, in the North Atlantic, Baffin Bay, Davis Strait, the Firth of Forth, and in the estuary of the Thames; and have even been caught in the Mediterranean and Adriatic; they chiefly live on the sepia or cuttle-fish, &c., in the deepest parts of the warmer seas within or near the tropics.

The family of the Whalebone whales consists of the common Greenland or Right whale (*Balæna Mysticetus*) and Rorquals (*Balænopteræ*). These colossal inhabitants of the frozen seas feed on medusæ and other small marine animals, which they catch by means of the moveable plates and filaments of whalebone in their upper jaw. The Right whale is from 65 to 70 feet long, but they are so much persecuted that they probably never live long enough to attain their full growth. The head is very large, but the opening of the throat is so narrow that it can only swallow very small animals. It has no dorsal fin, the swimming paws are about nine feet long, and the flat tail is half-moon shaped. It has two spouts or nostrils, through which it throws jets like puffs of smoke some yards high. It only remains two or three minutes on the surface to breathe and then goes under water for five or six. The back and tail are velvet-black, shaded in some places into grey, the rest is white; some are piebald.

The Right whale swims slowly and is timid, and the capture of it is often attended with much cruelty on account of its affection for its young; indeed, the custom of killing the calf in order to capture the mother has caused much prejudice to the fisheries in both hemispheres. Formerly the Right whale abounded everywhere within the Arctic circle, and was profitably fished for in the Atlantic; now it is rarely to be seen in the Spitzbergen and Greenland seas, it is scarce in Hudson Bay and Davis Strait, and is only to be met with in numbers to the N. of Lancaster Sound; and that in a few years will be fished out in its turn. The number of whale-ships has been annually diminishing, and it is evident that the trade will ere long come to an end. An extensive fishing-ground has been discovered by the ships sent in search of Sir John Franklin within Behring Strait; but as the whale here also is pursued in the same reckless manner by the whalers of the United States, it will likewise soon cease to be remunerative.

The whale found in such multitudes by Sir James Ross in the shallow water on the coasts of the Pacific and in the Antarctic Ocean, must be of a different species from the Right whale, to which the tropical waters would be like a sea of fire, since it cannot endure and never enters, warm water.

There are some whales peculiar to the North Pacific. The inhabitants of the Aleutian Islands mention four species.

Rorquals are also Whalebone whales, differing from the Right whale by their more elongated form. The great Rorqual, or Rorqualus Borealis, from 80 to 100 feet long, is the largest of marine animals. It is chiefly met with along the edge of the ice in the seas round the island of Jan Mayen, between Bear and Cherry islands, Novaia Zemlia, Spitzbergen—in fact, between the northern parallels of 70° and 76°; and in open seasons it reaches as high as 80°; nevertheless it travels to lower latitudes in pursuit of herrings, and other fish, and is occasionally seen off and in the Firth of Forth.

It had been caught on the coast of Norway as early as the year 890, and probably long before. The first northern navigators were not attracted by the whale as an object of commerce, but stumbled upon it in their search for a N.W. passage to the Pacific. The lesser Rorqual lives in the rocky bays of Greenland in summer, and is found on the coasts of Iceland, Norway, the Hebrides, and along the coasts of Scotland. The number of whales of all kinds that occasionally visit the Firth of Forth is very remarkable; the author has frequently seen several spouting at the same time, when shoals of herrings were coming up this estuary. There may be another reason for their visits. When a whale feels itself uncomfortable from the number of parasitical animals, chiefly of the Barnacle tribe, that have attached themselves to its skin, it rolls and tumbles about in the brackish water in the estuaries of rivers till it has got rid of them, aware that fresh water kills these animals. The bottoms of ships encumbered by marine parasites are divested of them in the same way.

The Humpback whale, or Balæna gibbosa—a rorqual 30 or 40 feet long—is met with in the intertropical and southern regions of the Pacific and Atlantic: it is seldom molested by whalers, and is very dangerous for boats from the habit it has of leaping and rising suddenly to the surface.

None of the senses of the whale tribe are very acute: the Whalebone whales appear to have the sense of smelling more so than the others; and although the Sperm whale is immediately aware of a companion being harpooned at a very great distance, it does not hear well in air, and none appear to have any voice.[1]

The Manatus and Dugong form a very small part of the cetaceous family; they are herbaceous and tropical. The Lamantin, a species of the former, lives in some rivers of Western Africa, which it ascends to a considerable distance from the sea; and another species is found in the rivers Amazon and Orinoco, where it is known as the sea-cow. Its body is round, and sometimes 12 or 15 feet long, and it browses in herds on the herbage at the bottom of the streams.

The Dugong is an inhabitant of the eastern Archipelago and of the shallow parts of the Indian Ocean, where it feeds on seaweeds; it is more a marine animal than the Lamantin, is scarcely ever seen in fresh water, and is so harmless that it allows itself to be handled. When it suckles its young it swims upright, which has probably given rise to the fable of the mermaid. This animal, like the Lamantin, will sacrifice its life for its young, and is hence held as a type of maternal affection among the Malays.

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[1] Scoresby's 'Arctic Voyages.'

The animal called the Manatus Septentrionalis, or *Rhytina*, which formerly frequented the Arctic seas of Northern Asia, is probably one of the herbivorous cetacea: it is supposed to be extinct.

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CHAPTER XXXII.

DISTRIBUTION OF REPTILES.

§ 1. Partial distribution of reptiles over the globe. § 2. Classification of reptiles. § 3. The Batrachians or frogs; their characteristics and habits. § 4. The Ophidians or serpents; prevalence of the class in intertropical regions; three groups of venomous serpents; six genera of innocuous serpents; fresh-water snakes; boa constrictors; pythons, sea-snakes. § 5. The Saurians or lizard tribe; crocodiles; alligators; lizards; dragons, or winged lizards; chameleons; anolis; skinks; burrowing saurians; sea-lizards. § 6. Emydians or tortoises and turtles; their characteristics; land tortoises; freshwater tortoises and turtles; hawk's-bill or "tortoiseshell"-yielding turtle; oil-producing turtles; lyre-turtles. § 7. Difference of species in reptiles of the Old and New World; their total absence from some islands.

§ 1. REPTILES, more than any other class of animals, show the partial distribution of animated beings, owing to their inability to travel to any great distance; and as they inhabit deserts, forests, and uncultivated ground, they have been little disturbed by man, who has only destroyed some individuals, but has not diminished the number of species, which, however, is small in comparison with those that existed in the Secondary geological periods. Of the mammalia but few hybernate, or fall into a torpid state in winter, such as the bear, marmot, dormouse, &c. Their fat supplies the carbon consumed by the oxygen during their feeble and imperceptible respiration, and is wasted by the time the warm weather returns, which rouses them from their lethargy, thin and extenuated. But reptiles, being colder blooded, bury themselves in the ground, and hybernate during the winter in cold and temperate climates. In hot countries they fall into a state of torpor during the dry season, so that they have no occasion to wander either on account of temperature or want of sustenance; and the few that do migrate in quest of food always return to their old haunts. As the blood of reptiles, from the peculiarity of their circulation, receives only a small part of the oxygen they inhale, little heat and strength are generated, and they are for the most part sluggish in their motions, which, however, are more varied than in mammalia; but as some reptiles, such as tortoises and lizards, breathe more frequently than others, there are consequently great differences in their powers of locomotion and sensibility.

§ 2. The order of Reptiles is divided by naturalists into four families, commencing in the ascending order:—1. Batrachians or frogs, including toads and salamanders; 2. Ophidians or serpents; 3. Saurians, including crocodiles, lizards, chameleons; and 4. Emydians or tortoises, and turtle. With very few exceptions, all reptiles are oviparous, or produce their young from eggs; they partake of both terrestrial and aquatic forms, and many are amphibious; they all increase in numbers towards the equator, and few live in the colder latitudes; but they can endure a cold winter better than a cool summer. Frogs and salamanders have been seen on the banks of the M'Kenzie river in North America, where the mean temperature is between 7° and 8° of Fahrenheit, and where the thermometer in winter even sinks to 90° below the freezing-point. The Rana temporaria lives as high on the mountain slopes as the snowline, the Rana alpina at the height of 4500 feet, and the Anguis fragilis at an altitude of 7700 in the Pyrenees. The extreme southern limit of reptiles, so far as it is known, is in 50° S. lat., where a species of frog was found on the banks of the river Santa Cruz.

The number of species of reptiles in the torrid zone is at least double that in the temperate; Australia has fewer than Europe; and of all places in the Old World, Java is perhaps the richest in animals of this order. America possesses more than half of all the species known, the maximum being in Brazil, but every one of them is peculiar to the New Continent.

§ 3. The Batrachians approach nearest to the nature of fishes, and form a link between aquatic and terrestrial animals. In their imperfect state of tadpoles they have tails and no feet, but when full-grown they generally acquire feet and lose their tails. In that early stage they are aquatic and breathe by gills; but in a state of maturity they breathe by lungs like quadrupeds, though some of the genera always retain their gills and tails, and some never acquire feet. These animals have the power of retarding and accelerating their respiration without stopping the circulation of their blood, so that they can resist heat and cold to a certain degree—a power most remarkable in the salamander, so varied in appearance and nature, which forms part of this class. Some, as toads and frogs, imbibe a quantity of water, which is evaporated through the pores of the skin, and aids to maintain them at the temperature of the medium they live in.

The group of toads and frogs consists of four genera, which have four feet, but without tails; namely, frogs, hylas or rainettes, toads, and pipæ. Frogs, which are amphibious, have no nails on their toes, and their hind legs are longer than the fore, and webbed, consequently better fitted for swimming and jumping, which they do by leaps. There are above 50 species, so that they are more numerous and more varied than any other genus of reptiles. The hylas or tree-frogs are all of the most vivid and brilliant tints, and several colours are frequently united on the same species. They mostly live on trees, and their feet have little cushions at the extremities of the toes, forming a kind of sucker, by means of which they can squeeze out the air, and, by the pressure of the atmosphere, they adhere firmly to the underside of the smoothest leaf, exactly on the same principle by which flies walk on the ceiling of a room. The Bufo, or Toad, is the ugliest of the Batrachians; many are hideous, with swollen bodies, the skin covered with wart-like excrescences, and obtuse toes. They seldom go into water, but frequent marshy damp places, and only crawl, whereas the frog and hyla leap. They are less numerous than either of the other genera; about 30 species are known. The common toad is capable of being tamed, and even of attachment. The Pipæ are also toads of a still more disgusting form, and are distinguished from their congeners by not having an extensile tongue. All these reptiles produce a noise from the lungs, which is exceedingly varied; they croak in concert, following a leader, and when he becomes tired another takes his place. One of the North American frogs croaks in bands; one band begins, another answers, and a third replies, till the noise is heard at a great distance; a pause then takes place, after which the croaking is renewed. Mr. Darwin notices a small musical hyla at Rio de Janeiro, which croaks a kind of harmony in different notes.

Toads and frogs are found in almost all parts of the earth, though very unequally and very partially distributed. America has more than all the other countries taken together, and Europe the fewest. Six species of frogs, one rainette, and two toads are European; and all, except four of the frogs, are also found in Asia and Africa. The Rana temporaria lives at the height of 7700 feet in the Pyrenees, and near the snow-line on the Alps.

None of this family exist in the Galapagos Islands, nor in any of the innumerable islands of Oceania: there are few in Australia, and these, like its quadrupeds, are peculiar to it. The absence of Batrachians from oceanic islands is one of the most interesting facts in the distribution of organic life, and is explained by the impossibility of the conveyance of the spawn by oceanic currents or in logs saturated by sea-water.

The great extent of marshes, rivers, and forests, together with the heat of the climate, make America the very home of reptiles of this family, and there they grow to a greater size than anywhere else:

a great number of species of frogs, tree-frogs, and toads are indigenous in that continent, not one of which is the same with those in the Old World; and most of those in South America are different from those in the northern division of that continent. All these reptiles have abodes with fixed demarcations, often of small extent. The Pipa, or large toad of Surinam, is the most horrid in appearance of the tribe; the Bufo agua of Brazil, 10 or 12 inches long, and the Rana pipiens or bull-frog of Carolina, are the largest.

The second division of this family of reptiles have tails and feet, as the salamanders, which are like lizards in their general form, having a long round or flattened tail and four feet. Some are terrestrial, others aquatic; the former are known as salamanders, the latter as newts or tritons. Both are found in Europe, but the greater number are American. The amphibious genera of Amphiuma, Menopoma, and Syren, possessing both lungs and gills, are American; the latter are peculiar to the marshes and rice-grounds of Carolina, and the Axolotl is only found in the great lake of Mexico. The Proteus anguinus, of a light flesh-colour, with four little feet and a flat tail, has been hitherto met with only in the dark subterraneous caverns of Carniola.

The 5th group of this order of Batrachians are the Cæciliæ, of which there are very few species, all inhabitants of the warm parts of Asia, Africa, and America. They have a cylindrical body, without feet, and move like serpents, thus forming a kind of link between the latter family and that of Batrachians. In South America they are supposed to live in the nests of ants.

§ 4. Serpents are met with in all hot and temperate countries, but they abound most in the intertropical regions. They are most numerous in the islands of the Indian Archipelago; whilst in those of the Pacific they are few. Java contains 56 species, which is a greater number comparatively than any other country of a similar extent; while in Borneo much fewer have been found. Those in Japan are peculiar to this group of islands. Wherever innocuous snakes exist, there also are some of the venomous kinds, but they are fewer specifically and individually. Only about one-fifth of the species of serpents are venomous, although that proportion is not everywhere the same. In sterile, open countries, the proportion of venomous snakes is greater than in those that are covered with vegetation. Thus, in Australia, seven out of ten species are poisonous; and in Africa, one of every two or three is noxious. In general, however, the number of harmless individuals is 20 times as great as the number of the poisonous.

The three groups of venomous serpents are the colubriform or adder-shaped snakes, the triangular-headed, and sea-serpents.

The adder-formed snakes are divided into several genera.
Elaps are slender like a cord, with a small head and of bri
colours. There are four species in South America, of
two are confined to Guiana, and one to Surinam, while the
is found everywhere from Brazil to Carolina. There is onl
in Africa, three in Australia, and the rest are in limited di
in tropical Asia, especially in Sumatra and Java; and an
genus is found only in India and the islands of Ceylon and
The hooded snakes (or Cobra di capello) are the best kno
this family, especially the spectacled or dancing snake of the I
jugglers, which is common from Malabar to Sumatra; two
species are peculiar to Sumatra and Java. The three or
African species are chiefly met with at the Cape of Good Hop
on the Gold Coast; but the most celebrated is that generally k
as the Egyptian asp, which has been tamed by jugglers in an
and modern times, and is frequently figured on the Egyptian r
ments; it derives some of its celebrity from having been the
posed cause of Cleopatra's death. Two of the genus in
Australia, one of which is hooded, but a different species from
of India.

The second venomous group consists of the triangular-h
serpents, rattlesnakes, and vipers. The first are of a hideous
—a large head, like a heart, broad at the base; a wide mouth,
their hooked poisonous fangs strongly developed. They q
watch their prey till it is within reach, then dart upon it, and i
the deadly wound in a moment. The yellow viper of the F
West Indian islands, the Trigonocephalus lanceolatus, is one
most dangerous snakes in existence. One species in the Old
is to be met with from Ceylon to the Philippine Islands; an
is a native of Sumatra, Timor, and Celebes; two are confin
Java alone. Ceylon, Sumatra, Japan, and Tartary have ea
peculiar species of this group.

The Crotali, or rattlesnakes, are all American—two live i
warmer districts of the Northern States, and two in the intertr
regions of South America. One of the latter, however, has a
horn at the end of its tail, instead of a rattle, and sometimes
to the length of 10 feet, being, with the Trigonocephalus
longest of the venomous ophidians.

Vipers extend farther N. than any other of the noxious
two are Asiatic, though one is also common to Africa, which,
ever, has four peculiar to itself; the only venomous serpen
Europe are three species of viper, one of which is also spread
the neighbouring parts of Asia and Africa. The common
inhabits all central Europe and temperate Asia, as far as
Baikal, in the Altaï Mountains: it is also found in Englan

Sweden and the N. of France, but does not cross the Alps, beyond which it is replaced by a distinct species frequenting dry soils in the S.E. of Europe, and which alone is met with in Styria, Greece, Dalmatia, and Sicily; and the Aspic viper, which lives on rocky ground, inhabits France between the Seine and the Pyrenees, Switzerland, Italy, and Sicily.

There are many genera of innocuous serpents, consisting of numerous species. They are mostly terrestrial, and their species are very limited in their domicile, the greater number being confined to some of the islands of the Indian Archipelago, Ceylon, or to circumscribed districts in tropical Asia, Africa, and America. Nine or ten species are European, some of which are also found in Asia and Africa.

Tree serpents of various genera live only in the great tropical forests of Asia and especially of America. They are long and slender, the head for the most part ending in a sharp point, and generally green, though there are some of brighter colours; many of these serpents are fierce, though not venomous; some feed on birds, which they watch, hanging by the tail from a bough.

In all temperate and warm countries abounding in lakes and rivers fresh-water snakes are numerous; some live entirely in the water, but they mostly inhabit the banks near it; they are excellent swimmers, and may be seen crossing lakes in shoals. America is particularly rich in these aquatic species, there are several in Asia, but they are rare in Africa, and none have yet been discovered in Australia.

The genus Boa is peculiarly American. The boa constrictor, generally from 9 to 15 feet long, lives in the great tropical forests of South America, where it often watches its prey, hanging by the tail from the boughs of trees. Two of smaller size have similar habits, and two are semi-aquatic, one of which, the Anaconda, is 20 feet long, and another 6; the latter live on the banks of rivers from the Amazon to Surinam; and a species is found at the foot of the Andes of Quito, at an elevation of 3000 feet.

Pythons are the largest snakes of the eastern continent, where they represent the boas of the western: one species, which sometimes attains the length of 20 feet, is spread from the western coast of Africa, throughout tropical Asia, to China and Java. Another, 14 feet long, is confined to Malacca and some of the Sunda Islands. Two others are found in the island of Timor, and one in Australia. There are only two species of Acrochordi, which, like boas and pythons, twist themselves round their victims and crush them to death: one aquatic, peculiar to Java; the other is a land-snake, very generally distributed from India to New Guinea.

The West Indian islands possess the snakes of the adjoining continent of America, and some confined to themselves; many in

Central America are not found elsewhere. The snakes of Madagascar are almost all peculiar to that island.

Sea-snakes frequent the Indian Ocean, from the Bay of Bengal to the Philippine Islands; they never enter fresh water.

§ 5. Saurians have representatives in every warm and temperate climate. The crocodile, from its size and ferocity, claims the first place. There are several genera of this family, all amphibious, living in rivers or in their estuaries. True crocodiles occur in Asia, Africa, and the West Indies; the oldest known species inhabits the Nile and all its tributaries, but appears to have been extirpated in the Delta. It is found in all the river systems of Soudan, Senegambia, and probably in that of the Zambesi, but there seems to be a distinct species about Sierra Leone.[1] The Gavials, which approach nearest to the form of certain fossil crocodiles, are Asiatic, and extend from Western Australia, through the Indian Archipelago, to all the rivers of India: there are three species, of which the Gavialis Gangeticus is the most celebrated; another species inhabits the Euphrates. The Alligators or Caymans, peculiar to the American continent and the West India islands, have a very extensive habitat; they are met with in all the rivers from 31° S. lat. through South, Central, and North America, to 32° 30′ N. lat. They are most numerous in the estuaries of the great rivers, but they are found as high as 3000 feet at the base of the Andes of Quito, and they are known in some of the rivers of Bolivia at a much greater elevation.

The alligators of the Mississippi, and of the rivers and marshes of Carolina, are more ferocious than those of South America, attacking men and animals; they only prey in the night; like all their congeners, they cannot swallow their food in the water, but they drown the animal they have caught, hide it under water till it becomes putrid, and then drag it on shore to devour it. Locality has considerable influence on the nature and habits of these animals; in one spot they are very dangerous, while in another, at no great distance, they are cowardly. Alligators are rarely more than 15 feet long, and are seen in large herds basking on the banks of rivers: their cry is like the roar of a bull: in a storm they bellow loudly, and are said to be much afraid of some of the porpoise family that ascend the great American estuaries. The female watches her eggs and her young for months, never losing sight of them; but the male devours many of them as soon as they leave her. All animals of this class are covered with scales, which are hard, horny, often bony, and impenetrable.

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[1] The most celebrated species of this division is the crocodile of the Nile, which probably is to be met with in the upper branch of that river, the Bahr-el-Abiad, as high as 4000 feet above the level of the sea. Immense numbers of this animal, of every size and age, are found embalmed in the catacombs of ancient Egypt, and they are perfectly identical with the existing species, offering another proof of the important fact first announced by Cuvier, from his examination of the mummies of the ibis, &c. &c., that no animal, in its wild state, had presented the least change since the most remote historical period.

Lizards are chiefly distinguished from crocodiles by having a long thin, forked tongue like that of the viper; by their rapid motions, smaller size, and by some peculiarities of form.

The Monitors, which are entirely confined to the old continent, have the tail compressed laterally, which enables them to swim rapidly; and they are furnished with strong sharp teeth. Many species inhabit Africa and Asia, especially the Indian Archipelago: the monitor or terrestrial crocodile of Herodotus is common on the deserts which enclose Egypt; and an aquatic species in the Nile, which devours the crocodile's eggs, is often represented on the monuments of the ancient Egyptians.

Another group allied to the monitors is peculiarly American: some of the species inhabiting the marshes in Guiana are six feet long.

Lizards, properly so called, are very common; more than 63 species are European, of which 20 inhabit Italy, and one lives on the Alps at an elevation of 4500 feet; the group of the Iguanians, which differ from them chiefly in the form of the tongue, is so numerous in genera and species, that it would be vain to attempt to follow all their ramifications, which are nevertheless distributed according to the same laws as other creatures: but the dragons, only found in India, are too singular to be passed over. The dragon is a lizard with wings formed by an extension of the skin, which is spread along its sides and supported by outstanding long and slender ribs, attached to the fore and hind feet, as we see in the flying squirrel amongst the mammalia, and, though they do not enable it to fly, they act like a parachute when the animal leaps from bough to bough in pursuit of insects. Nocturnal lizards of many species inhabit the hot countries of both continents; they are not unlike salamanders, but they have sharp claws to seize their prey with, which they can draw in and conceal like a cat. One of the species of Gecko climbs on walls in most of the countries bordering on the Mediterranean. Chameleons are frequent in northern Africa; and several species inhabit different districts and islands in Asia: the only European species is found in Spain; it is also common in Northern Africa.

The Anolis, which lives on trees, replaces the chameleon in the hot regions of South America and in the Antilles, having the property common to chameleons of changing its colour, but it is a more nimble and beautiful animal. In Australia, where everything is anomalous, there is a lizard with a leaf-shaped tail, and another with a broad erectile hood.

Two anomalous saurians of the genus Amblyrhynchus were discovered by Mr. Darwin in the Galapagos Islands. One peculiar to the central islands is terrestrial, and in many places it has undermined the ground with its burrows; the other is the only lizard known that lives on seaweed and inhabits the sea: it is about four feet long, and hideously ugly, with feet partially webbed and a tail compressed laterally to adapt it for swimming. It basks on the beach, and in its marine habits and food it resembles, on a small scale, the huge fossil monsters so abundant in the older beds of our British secondary formations.

§ 6. Tortoises are covered with a shell or buckler, but their neck, legs, and tail are free, with a wrinkled skin, so that the animal can draw its head and feet into the shell when alarmed. The head is sometimes defended by a regular shield, and the jaws, instead of teeth, have a horny covering. The upper buckler is rounded, and formed of eight parts or plates, symmetrically, and often very beautifully, disposed; the under shell is flat, and consists of four pair of bones and one in the centre. One group of tortoises is terrestrial, two others are amphibious, one of them living in fresh water, the other in the tropical seas.

There are more land tortoises in Africa than in all the rest of the world, both specifically and individually. They abound also in the Sunda Islands, in North and South America, and especially Brazil. There are three European species, of which the common Tortoise (*Testudo Græca*), which is met with in the countries bordering on the Mediterranean, is the largest, attaining as much as a foot in length: it lives on insects and vegetables, and burrows in the ground in winter. Some of the East Indian species are enormously large, above three feet long, and remarkable for the beautiful distribution of their colours; certain species are peculiar to Brazil, one to Demerara, and one to North America; but perhaps the largest known species is that of the Galapagos Islands, the Testudo Elephantopus, or Test. Indica, which weighs 500 or 600 pounds.

The Chelonians, or sea-turtles, inhabit the seas of the torrid and temperate zones, as far as the 50th parallel of latitude, some living on seaweed, and others on small marine animals. Distinct species are found in different parts of the ocean. The green turtle, of which there are many varieties, inhabits the Atlantic within the tropics; they may be seen browsing on the seaweed at the bottom of the water along the coasts: they repair at certain seasons from distances of many hundred miles in great herds to the mouths of rivers to deposit their eggs in the sand. This turtle is often six or seven feet long, and weighs 600 or 700 pounds; it is much esteemed for food, but the shell is of little value. The hawk's-bill turtle, which furnishes the tortoise-shell of commerce, is caught in different parts of the Indian Ocean, among the Molucca Islands, and on the north-western coast of New Guinea. It is also found in the western hemisphere, on the coasts of Haiti and of the Caiman Islands, but the shell of this variety is less valuable than that from the eastern seas.

§ 7. With respect to the whole order of reptiles it is worthy of remark that not one species is common to the Old and New World; that those in Australia are altogether peculiar to that great continent; and that, as far as is at present known, with the exception of the Marianne Islands, there are neither toads, frogs, nor snakes in any of the Polynesian islands, though the Indian Archipelago abounds in them; neither are they found in Tierra del Fuego, on the coasts bordering the Strait of Magellan, nor in the Falkland Islands.

Five species of reptiles—a lizard, a frog, a toad, and two tritons—are found in Ireland, where they must have existed before its geological separation from England.

CHAPTER XXXIII.

DISTRIBUTION OF BIRDS.

§ 1. Classification of birds; species similar in the north of the Old and New Continents, but differ in the south. § 2. Migratory birds; their habits and powers of flight. § 3. Distribution of Arctic and European birds; large proportion of aquatic birds in the north; capabilities of web-footed birds to endure cold; cormorants; gulls; petrels; habits of insular and marine birds; variety of species of British birds; vultures of Europe; owls; British birds of passage; sylvidæ; thick-billed birds; gallinaceæ; European waders. § 4. Birds of Asia and the Indian Archipelago; birds of northern Asia similar to European; Asia Minor a country of transition; gorgeous colours of the birds of the Gangetic region; variety and splendour of the gallinaceæ of S. Asia; beauty of the birds of the Indian Archipelago. § 5. African birds; those of N. Africa similar to European; birds of the centre of the continent peculiar; those of S. Africa differ both from the North and from Europe; description of African birds. § 6. Birds of N. America; about one-fifth are common to Europe; humming-birds peculiar; N. America the home of the turkey; the region of numerous water-fowl and waders, owing to prevalence of water and marshy ground. § 7. Birds of S. America; variety of original forms greater than in any other country; numerous species of humming-birds; gallinaceæ differ from those of the Old World; wide range of the ostrich; great variety of water-fowl. § 8. Australian birds; these as peculiar as the quadrupeds and plants; extinct birds and those that are rapidly disappearing.

§ 1. MORE than 7500 species of birds are known, which, according to the most generally adopted classification, are arranged in eight natural orders or groups, namely, Birds of prey—or vultures, falcons, owls; Perching birds, by much the most numerous, comprising the songsters; Climbers, as parrots, woodpeckers, cuckoos, &c.; Pigeons; Gallinaceous birds, including our domestic fowls, partridges, grouse, pheasants, ostriches; Waders, as snipes, herons, curlews, &c.; Web-footed birds, as ducks, petrels, &c., and Strathiones or ostriches. Next to tropical America, S. Asia is richest in species; the greatest number of birds of prey inhabit Southern America, which surpasses every country in the number and beauty of its ornithological species.

There is much similarity in the birds of the northern parts of the old and new continents, and some few species are identical. Towards the S. the forms differ more and more, till in the tropical and southern portion of the temperate zones of Asia, Africa, and America they entirely differ, whole families and genera often being confined within very narrow limits. Some, however, are almost universally distributed, especially birds of prey, waders, and aquatic species.

§ 2. Birds migrate to very great distances in search of food, passing the winter in one country and the summer in another. As in cold climates insects die or hybernate during winter, and between the tropics either perish or sleep in the dry season, so, in both cases, insect-eating birds are compelled to migrate. When the ground is covered with snow, the want of seeds forces those whose food is vegetable to seek it elsewhere; and in tropical countries the annual inundations of the rivers regulate the migrations of birds that feed on fish.

Some migrate singly, some in groups, others in flocks of thousands; and in some instances the old and the young birds travel separately. Those that fly in large flocks generally have a leader, and such as do so in smaller numbers observe a certain order. Wild swans fly in groups in the form of a wedge, wild geese in a line. Some birds are silent in their flight, others utter constant cries, especially those that migrate during night, as herons, goat-suckers, and rails, to keep the flock together.

Birds of passage in confinement show the most insurmountable uneasiness as the time of migration draws near. The Canadian duck rushes impetuously to the N. at the usual period of summer flight. The American robins, goldfinches, and hangnests, brought from Canada to the North American States when young, dart northwards, as if guided by the compass, as soon as they are set at liberty. Birds return to the same place year after year. Storks and swallows take possession of their former nests, and the times of their departure are exact almost to a day. Various European birds spend the winter in Asia Minor and Northern Africa; while many natives of these countries inhabit central Europe in summer.

The birds of passage are more numerous, both in species and individuals, in America than in any other country. Ducks, geese, and pigeons migrate in myriads from the severity of the northern winters in search of a more genial climate; and when there is a failure of grain in the south, different families of birds go to the north. The Virginian partridge crosses the Delaware and goes to Pennsylvania when grain is scarce in New Jersey; but it is so heavy on the wing, that many out of the flocks fall into the river and end their journey by swimming.

The same thing happens to the wild turkey, which is caught by hundreds as it arrives wet on the banks of the Ohio, Missouri, and

Mississippi. These birds are not fitted for long flight by their structure; their bones have fewer of those air-cells which give buoyancy to the feathered tribes.[1] The number of air-cells is greatest in birds that have to sustain a continued and rapid flight. The extremes are to be met with in the swift and the ostrich—the one ever on the wing, the other never—besides, the one has exceedingly long wings, the other hardly any. The strength of the ostrich is in the muscles of its leg; while the muscles on the breast of the swift weigh more than all the rest of the body; hence it is said to fly at the rate of 100 miles an hour. The wild duck and the wild pigeon fly between 400 and 500 miles in a day. The stork, quail, and some other migratory birds do not halt till the end of their journey. Many sea-birds are never seen to rest; all birds of prey, such as the eagles, vultures, and hawks, are of strong flight, and capable of sustaining themselves at heights beyond the reach of less buoyant creatures.

DISTRIBUTION OF ARCTIC AND EUROPEAN BIRDS.

§ 3. The birds of Europe and North America are better known than those of any other part of the globe. New species are constantly discovered in Asia, Africa, and South America.

There are about 600 species of birds in Europe, many of which are distributed over Asia and northern Africa, without much apparent variation. Many of our European species are also found in North America, but nearly the whole of these latter are marine birds of our northern latitudes, which, like all sea-fowl, have a wide range.

More than three-fourths of the species, and a much larger proportion of individuals, of the birds of Greenland, Iceland, and Färoe, are more or less aquatic, and many of the remainder are only occasional visitors. Of the few small birds, the greater number are British species; but many that reside constantly in Britain are migratory in Iceland and Färoe; all the small birds leave Greenland in winter. Waders are more numerous than land-birds in the

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[1] The quills of birds' feathers are full of air, and the hollow cavities in their bones are so many air-cells, which they can fill at pleasure. In birds that ascend to great heights like the Condor, the air in the bones is connected with the lungs by larger openings than in other birds, to enable them to breathe freely where the air is so much rarefied. To birds of long and high flight, as in the birds of passage, length of wing is also necessary.

The Gannet or Solan goose can force air between its skin and its body, which makes it extremely buoyant on the water, and enables it to bear the cold of the stormy northern seas on which it lives.

Arctic regions. The snipe and the golden plover are birds of passage; the oyster-catcher remains all the year in Iceland, where it makes its nest near streams, and wages war with the crow tribe. The heron, curlew, plover, and most of the other waders, migrate; sandpipers and the water-ousel remain all the year round.

Web-footed birds, being clothed with down and oily feathers, are best able to resist the cold of a polar climate. Various species of the duck tribe live in the far N., in prodigious multitudes. The mallard, supposed to be the origin of our tame duck, is found everywhere in the Arctic lands. There are two European species of eider-duck: the true eider, *Somateria mollissima*, is widely dispersed over the islands and coasts of the North Atlantic, and all the Arctic regions in Europe and America. The second European species is the King-duck (*Somateria spectabilis*).

Cormorants, which live on fish, are universally distributed over the northern seas, but are scarcely ever eaten by the natives. The cormorant sits singly, or sometimes in flocks, on the rocks, watching the fish with its keen eye: it plunges after them, and pursues them for three or four minutes under water. Auks are very numerous, especially the razor-billed auk; but the great auk, which is incapable of flight from the smallness of its wings, is now nearly extinct in the Northern seas. Terns, or sea-swallows, are seen everywhere in these seas, skimming along the surface of the water, devouring mollusca and small fish. Gulls of many species, and in countless thousands, are inhabitants of the Arctic regions, while the temperate and tropical seas are tenanted by the equally numerous genus Procellaria, or Petrel. No birds are more widely dispersed than this genus. They are at home and brave the storm in every latitude and in every sea.

The South Pacific and the Antarctic seas are the favourite resort of petrels. They take their name from the faculty they have of skimming the waves with their legs hanging down, giving them the appearance of walking on the water,[1] in which they are aided by their very large flat webbed feet and widely-extended wings. The stormy petrels, consisting of several distinct species, about the size and colour of a swallow, the tempest-bird or Mother-Cary's-chicken of the sailors, are the most widely diffused; their flight is rapid; they shelter themselves from the storm in the hollow of a wave, and go to land only at the breeding season.

The greater part of the marine birds of the Arctic seas are inhabitants also of the northern coasts of the continent of Europe, and visit the British islands.

Few parts of Europe are richer in birds than Britain, both in species and the number of individuals; and the larger game is so abundant, that no one thinks of eating the songsters and other small birds, as we see in the S. of Europe. Of the nearly 600 species of European birds, 277 are found in our islands. It is probable that most of the British birds came from Germany before the separation of our island from the continent, and that many of short flight never reached Ireland.

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[1] Petrel, from St. Peter.

There are five European species of vulture: the Lämmergeyer of the Alps and Pyrenees builds its nest in the most inaccessible parts of the mountains, and is seldom seen; it lives also on the mountains of Northern India, Abyssinia, and in the steppes of Mongolia. Ten species of eagle are European; one is peculiar to Italy and Northern India; and few if any of them are common to America. The golden eagle is perhaps an exception; that beautiful bird, which once gave a characteristic wildness to our Scottish mountains, and the distinguishing feather to the bonnet of our Highland chieftains, is now nearly extirpated, and so are some of our numerous hawks. Among others, the jer or gentil falcon has been so much hunted down, that it is now rare even in Iceland, its native place: there are still a few in Scotland, and several are caught in their migratory flight over the Low Countries and trained by the expert falconers for the now nearly obsolete sport of falconry.

The owl tribe is numerous, and many of them are of beautiful plumage. The *Bubo maximus*, or great horned owl, the largest of our nocturnal birds, inhabits the forests of central and southern Europe; it is rare in France and England, though not uncommon in Ireland and Orkney: in Italy a small owl is tamed and used as a decoy in the capture of smaller birds.

The two species of our European goatsuckers migrate to Africa in winter; their peculiar cry may be heard in a moonlight night when a large flock takes wing for the journey. Our swallows go all to Northern Africa: one of our kingfishers (*Alcedo hispida*) is resident; the other (*Ceryle rudis*) is a native of Lower Egypt and the shores of the Red Sea, and only occasionally found in southern Europe.

The Sylvidæ have soft and pointed beaks, and feed on insects and worms; the nightingale, the robin-redbreast, the wren, the smallest of European birds, the warblers, and white-throat, belong to this family. Four species of fly-catchers are found in Europe, and five species of shrikes. The Fringillidæ or thick-billed birds are numerous in Europe; to them belong some of our finest songsters. Compared with America the starling family are few in species, as well as the woodpeckers, of which we have six, some very beautiful. There is only one cuckoo purely European; the other two species that visit us arrive only accidentally, and all are birds of passage. There are four species of pigeons: the ringdove frequents the larch forests, and is permanent; the stockdove leaves us in October; the Biset or rock pigeon, supposed to be the parent bird from which the infinite variety of our domestic pigeons has sprung, flies in flocks, and makes its flimsy nest on rocks on the sea-coast. Of gallinaceous birds we possess many: the pheasant has been introduced from the adjoining parts of Asia; the capercailzie, or gigantic black grouse, for many years extinct in the British forests, but recently restored to Scotland, still inhabits many parts of Europe; in Scandinavia especially it is plentiful as far as the pine-tree grows, which is nearly to North Cape, and also in the Russian forests. The hazel grouse frequents the pine and the aspen forests in central and northern Europe, where the black-cock also is plentiful. Five species of grouse and six of partridges afford abundance of game; four of the latter are confined to the southern parts of the continent, and so are the sand-grouse, which form a separate genus. They inhabit the sterile plains of Andalusia and Granada, southern Italy, and Sicily.

European waders are very numerous, and among them there are species of most of the described genera; woodcocks, snipes, plovers, and curlews are very abundant, and herons of various species; there are three species of egret or crested heron, and the common heron now assembles on the tops of trees unmolested, since the progress of agriculture has rendered the country unfit for hawking. Two species of cranes, a stork, and two of ibis, are met with in Europe: a flamingo lives in the south-eastern parts of the continent, and in the Maremma or plains on the western coasts of Italy. Many of the waders, however, migrate in winter. The stork, so great a favourite in Holland that it is specially protected, is migratory; it retires to Asia Minor and Africa, and, on the return of summer, resumes its former nest on a chimney-top, breeding in both countries. About 140 species of European birds either live in the more elevated parts of the Alps, or cross them in their annual migrations. They generally take their flight by the Great St. Bernard, the pass of St. Théodule, the Simplon, and St. Gothard. Europe is particularly rich in aquatic birds; there are three species of wild swans, four of geese, and more than 30 of the duck tribe, including those that inhabit the Arctic seas.

BIRDS OF ASIA AND THE INDIAN ARCHIPELAGO.

§ 4. European birds are widely spread over Northern Asia; most of the Arctic sea-fowl frequent its northern coasts; between 50 and 60 European birds are also Siberian, and there are above 70 European species in Japan and Corea, which probably also extend to Siberia and the Altai Mountains, and some few are identical with the birds of N. America; so that the same affinity prevails in the feathered tribes of the Arctic regions as in their vegetable productions.

Asia Minor is a country of transition, and many European birds are mixed with those of warmer regions, as the *Halcyon Smyrnensis*, a bird with gorgeous plumage, identical with the great Bengal kingfisher so generally found in India. European birds also inhabit the Caucasus, the shores of the Caspian Sea, and Persia. Moreover, these warmer climates are the winter quarters of various European species.

Farther E. the types become more Indian; the great peninsulas on each side of the Ganges are the native countries of the most gorgeous of birds. Many species of kingfishers of the brightest colouring are found here; the plumage of the fly-catchers has the richest metallic lustre; and the shrikes, of a sober hue in our northern latitudes, are there decked in the most brilliant colours; the *Irene* has a coat of the brightest ultramarine blue, and the *Calyptomenœ* of Sumatra and Malacca one of an equally brilliant emerald green.

The large-beaked climbing-birds are singularly handsome. The small collared parakeet, so easily taught to speak, has inhabited the Indian forests and the banks of the Ganges time out of mind with a host of congeners of every colour; not one species of these, or indeed of the whole parrot tribe, is common to Asia, Africa, America, and Australia, nor even to any two of these great continents, except the collared species, which is found in Africa as well as India. They are vividly coloured in India, in which the numerous species of cuckoos rival them; several genera of birds of the cuckoo family exist nowhere else.

Southern Asia is distinguished by the variety of its gallinaceous birds and the gorgeousness of their plumage. To this country we owe our domestic fowls; and the two known species of peacock are wild in the woods of India and its islands. Some of the most brilliant birds of the East belong to the pheasant tribe, of which five species are peculiar to China and Tibet. There are various species of the pheasant in the Himalaya, whose feathers have a metallic lustre. The gold, the silver, and Reeves' pheasant, the tail-feathers of which latter are four feet long, are natives of China. The *Lophophorus refulgens*, and some others of that genus, are peculiar to the mountains of Northern India.

The pigeons also are very splendid in their plumage; they mostly belong to Southern Asia and the islands; several of those in the Birman empire are green.

It would be vain to enumerate the beautiful birds that live in the forests of the Asiatic continent, yet those of the Indian Archipelago far surpass them in splendour of plumage; these islands, indeed, are the abode of the most gorgeously arrayed birds in existence. Even in Java and Sumatra, though most similar to India in their winged inhabitants, there are many peculiar, especially several species of the climbing tribe and of the honey-sucking kind; but the dissimilarity increases with the distance, and in New Guinea and its adjacent islands the honey-sucking genera are developed in novel forms and sumptuous plumage, and the ornithology generally is more nearly allied to that of Australia.

Many genera are peculiar to India: and many others are found exclusively in the islands of the Indian Archipelago, several of which are limited to one or two islands. There we find the Cassicans, which resemble jays, with plumage of metallic lustre; various species of *Buceros* with large horned beaks, Orioles of vivid colours, the Swallow that builds the edible nest, numerous and splendid Sylvias, and many species of *Melliphagidæ* or honey-sucking birds, whose tongues terminate like a brush. Several species of Birds of Paradise inhabit New Guinea and the neighbouring Moluccas and Aroo Islands. They are birds of passage, and change their quarters with the monsoon. The King or Royal Bird of Paradise has two long slender filaments projecting from the tail, ending in a curled flat web of emerald green, and the male of the green species has long flowing plumes from the sides of his body, which give him a gorgeous appearance. The pigeons are peculiarly beautiful and numerous, but limited in their abode. The two species of *Goura*, or great crowned pigeon, the largest of their tribe, are inhabitants of New Guinea. Each island has its own species of Lories; many Parakeets, Cockatoos, Kingfishers, and Barbets with huge beaks, are peculiar to these islands. Even the partridges have changed their dull colours and assumed the vivid hues of the tropics. Other gallinaceous species far surpass them in beauty, as the Argus pheasant. One of the Cassowaries, a bird akin to the ostrich, without the power of flying, but fleet in its course, has a wide range in the Melanesian Archipelago, extending from New Guinea and North Australia to New Britain.

AFRICAN BIRDS.

§ 5. A great number of European birds are also inhabitants of Northern Africa; and many migrate there in winter, but the birds of the central part of the continent, S. of the great desert, are quite peculiar and characteristic. Those of the W. and N.E., and at the Cape of Good Hope, are best known, the greater part of tropical Africa being still unexplored by the naturalist. It may be observed generally that the South African birds differ from, but are, with few exceptions, corresponding species with those in the western and north-eastern parts of the continent, and that the whole of Africa S. of the desert differs in species from northern Africa and from Europe.

Africa possesses at least 700 species of the passerine order. Many kingfishers, the most beautifully coloured of their brilliant race, frequent the banks of the lakes and rivers: two species of hoopoes, one of which visits Europe in summer, and the honey-birds, sometimes erroneously called humming-birds, are peculiarly abundant in Africa. They abound at the Cape of Good Hope, where the nectaries of the Proteas and other plants furnish saccharine juice for their food. The canary-bird is confined to the Canary Islands; its song differs even in two adjacent districts: there are, however, instances of this among other species. Various genera of Bush-shrikes, many of which are remarkable for the soft and lax feathering of the lower back, are peculiar to Africa; likewise a very fine group of birds allied to the Starlings, conspicuous from their brilliant and glossy plumage. The Ox-picker or Buphaga, of which two species are known, is also highly characteristic of African ornithology. The Weaving-bird, or Ploceus textor, is one of the most remarkable of the granivorous tribe; it dexterously weaves its nest with grass and twigs. The Whidah-bird, several species of Bee-eater, the Colious, and all the Touracous or Plantain-eaters, with many species of Woodpeckers, are found nowhere else. The parrots, which are much less numerous than in Asia or South America, are of peculiar forms. One species of Trogon and several genera of Barbets are purely African, and so are some of the cuckoos. Among the latter are several species of the genus Indicator, so named from indicating where the bees have placed their nests; one of these is peculiar to Abyssinia, another to the interior at the Cape of Good Hope and the forests on the Zambesi.

To Africa we are indebted for the Guinea-fowl, of which there are six or seven species known: they wander in flocks of hundreds among the brushwood on the banks of rivers and lakes in all the tropical regions, and are even more abundant in Madagascar. Many species of gallinaceous birds are peculiar, especially the Gangas, of which there are no less than five; some unite in coveys, and others traverse the deserts in flocks of many hundreds. These birds are much more abundant on the arid deserts of North Africa than in Europe; the partridges in this country are represented by the francolin.

The ostrich occupies the wide range of Africa and Arabia; and bustards, also wanderers in the plains, are numerous: the most peculiar are the Houbara and the *Otis caffra*, in Southern Africa, the latter five feet high, remarkable for the brilliancy of its eye.

Waders of infinite variety inhabit the rivers, lakes, and marshes

—woodcocks, snipes, plovers, storks, cranes, herons, and spoonbills. The most peculiar are the Dromes and Marabous, whose feathers form a considerable article of commerce; the cream-coloured plover, the Scopus or Ombrette, the water-treader of Abyssinia, and the Tantalus or Curlew tribe, to which belongs the Ibis (Ibis religiosa), held sacred by the ancient Egyptians, so frequently found as mummies in the catacombs, and represented on their monuments, and the recently-discovered huge broad-billed heron, the *Balœniceps rex*, which inhabits the Upper branches of the White Nile, where it feeds on water-tortoises and lizards.

BIRDS OF NORTH AMERICA.

§ 6. Of more than 600 species of North American birds, about 100 are also found in Europe, the greater number of which are aquatic, and live on the northern coasts of both continents. The sea-birds of the North Pacific and Behring Strait very nearly resemble those in the Greenland seas and the North Atlantic; the great auk of our northern seas also exists on the North Pacific; and the large white albatross, seldom seen in the North Atlantic, frequents in immense flocks Behring Strait and the western coasts of North America. It is met with almost everywhere in the Pacific as far as the stormy regions near the Antarctic circle. Like the petrel it is a bird of the tempest, sailing calmly on its wide-spreading wings in the most tremendous gales, and following a ship for days, seldom resting on the wave: this and the giant petrel are the largest of winged sea-fowls; some measure 14 ft. between the tips of the wings.

There is no species of vulture common to the two continents, but there are eagles and other birds of prey, and several waders and web-footed birds: yet in their general character the birds of North America differ from those of Europe: about 80 American genera and two families are not found in Europe. The humming-birds are exclusively American; only four species are found in the Northern States. The Parrot family has but one representative here, which lives in the forests of the Carolinas. It is singular that a country with so many rivers and lakes should possess only one species of kingfisher. The woods are filled with many species of creeping birds, and there are numerous peculiar wood-warblers and tyrant-fly-catchers. Ravens, crows, pies, and jays abound. The finch tribe is very numerous, and there are 16 species of woodpeckers, as might be expected in a country covered with forests. Of pigeons there are eight species, but individually they are innumerable, especially the *Ectopistes migratoria*, which passes over Canada and the northern States in myriads for successive days twice in the year. Our poultry-yards are indebted to North America for the domestic turkey, which there ranges wild in its native woods and attains great size. There are no partridges, properly speaking, but the Ortyx, a genus closely allied, represents them, and, of 13 American species of grouse, only one probably is found in Europe. The vast expanse of water and marshy ground makes North America the favoured region of innumerable water-fowls and waders. Most of the waders and granivorous birds are migratory; in winter, finding no food N. of the great lakes, where the ground is frozen upwards of six months in the year, they are obliged to migrate to the S.; many, as Storks and Cranes, pass the winter in California; wild geese cover acres of ground near the sea, and when they take wing their clang is heard from afar. Even gulls and other northern sea-birds repair to the coasts of California, and to the temperate shores of all the North Pacific.

It may be said generally that, with regard to the web-footed order, North America possesses species of all the genera of the Old World, and many peculiarly its own. The table-land of Mexico has some peculiar forms, and a few species of swimming-birds found only in more northern latitudes.

BIRDS OF SOUTH AMERICA.

§ 7. The inhabitants of the air in South America differ more from those in North America than these latter do from the birds of Europe: there are not more than 50 or 60 species common to the two continents of the western hemisphere. South America has a greater variety of original forms than any other country; more than 200 genera with all their species inhabit that continent only; of the passerine family alone there are at least 1000 species, all peculiar to it. The vultures belong to different forms from those in Europe; the Condor of the Andes is the largest; it frequents the highest pinnacles of the Andes in summer, and builds its nest at the height of 15,000 ft. and more above the sea; Humboldt saw it wheeling in circles at the elevation of 22,000 ft. It inhabits the Andes from the Strait of Magellan to 7° N. lat., but it has never been seen N. of the Isthmus of Panamá, the Californian Condor being a different and smaller bird. It roams over the plains of Patagonia even to the mouth of the Rio Negro, and at times descends from the Andes to the sea-shore to feed upon dead whales; like all the vulture tribe, it possesses the faculty of discovering a dead or a dying animal from a very great distance. Although the Condor lives principally on dead animals, it will sometimes attack the living; its habits are those of our common vulture; its size and ferocity have been much exaggerated; the most remarkable point in its history is the great vertical extent at which it is known to live, from the level of the sea to an elevation of nearly four statute miles. The *Sarcorhamphus papa*, or king of the vultures, an inhabitant of the tropical regions, is remarkable for the bright blue and vermilion colour of its bare head and neck; the black vulture lives in large flocks on the high trees in the forests of Brazil, and extends as far northwards as southern Mexico: other species prey on animals in the llanos or plains. The Guacharo, or Fat-bird, which forms of itself the genus *Steatornis* is the size of a common fowl, with the form and beak of a bird of prey, and is a singular instance of a nocturnal bird feeding on fruit. It shuns the daylight, and is found under the natural bridge of Pandi, near Bogota, and in the caverns of Guadeloupe and Trinidad: incredible numbers have taken possession of the dark cavern of Guacharo in the valley of Caripe, where they are killed by thousands every year for their fat.

The Troupials represent our Starlings, the Bataras and Becardes our Shrikes, while the Tanagers, gaily-coloured members of the family *Fringillidæ*, show likewise some connection with the American Wood-warbler. The *Trochilidæ*, or humming-birds, are peculiarly characteristic of South America; 400 species of this group, from the size of a wren to that of a humblebee adorn the tropical regions of Brazil and Guiana. This family, so peculiarly American, has a range from the Strait of Magellan to the 38th parallel of N. lat.; it may be met with in the forests on the mountain of Orizaba at an elevation of 11,000 feet above the sea, and some beautiful species of it at still greater heights in the Andes of Bolivia and New Granada. There are only three or four humming-birds that visit the Northern States, but many are permanent in Central America: in some places these birds are migratory: they come in multitudes to northern Chile in summer, and disappear in winter. In British Columbia they appear in spring immediately on the melting of the snow, when the wild Ribes burst into blossom. The climbing birds, with large bills, are mostly confined to the tropical forests, which swarm with peculiar races of toucans, parrots, and macaws. Parrots range from the Strait of Magellan to the 42nd parallel of N. lat., where the Eider-duck, which is a peculiar Arctic bird, first shows itself. There are whole families of birds in tropical America not to be seen elsewhere: as the vividly-coloured Toucan, with its huge beak; the Aracari, some peculiar genera of the gorgeous Trogons; the Tamatias and Jacamars, which are both allied to the Kingfishers.

The gallinaceous family is totally different from that of the Old World; the Guan or Penelope, and the different species of Crax or Alectors, represent our pheasants, which they excel in size, but not in beauty of plumage; whilst the numerous species of Tinamous and cognate genera fill the place of the grouse, quails, and partridges of the old continent. South America furnishes two species of grallatorial birds of a very peculiar character—the Cariama of Brazil, like the secretary-bird of the Cape of Good Hope in its form and its instinct for destroying reptiles, although belonging to a different order; and the Kamichi, which possesses a sharp triangular spur at the point of each wing, an instrument of attack and defence such as is possessed by no other bird to the same extent.

The three-toed or American ostrich ranges, like all its congeners, over a wide extent of country. One species, the *Rhea Americana* is found from the forests of Brazil to the Rio Negro, which bounds the Pampas of Buenos Ayres on the S., and in some of the elevated plains of the Peru-Bolivian Cordilleras; while the *Rhea Darwinii* roams over the plains of Patagonia to the Strait of Magellan.

The water-fowl and waders in this land of rivers are beyond number; millions of Flamingoes, Spoonbills, Cormorants, Herons, and Fishing Falcons follow the fish as they go up the rivers to spawn; a little snow-white heron walks on the back and over the head of the alligator while it sleeps. The water-fowl are almost all peculiar. Eight or nine genera belonging to the warm climates of the Old World are here represented by new forms, and the number of specific forms of the same genus is greater than in any other country. The splendid red Ibis, or *Ibis rubra*, inhabits Cayenne; the *Eurypyga helias*, the most beautiful of the heron tribe, from its variegated plumage, is found in the same country.

Ducks migrate in immense flocks, alternately between the Orinoco and the Amazons, on account of the greater supply of fish afforded by the floods of these rivers, which take place at intervals of six months from each other. Between the tropics the vicissitudes of drought and humidity have much influence on the migration of birds, because the supply of their food depends upon these atmospheric changes.

If anything more were required to show the partial location of the feathered tribes, the Galapagos Archipelago might be adduced as an example. Of 26 birds collected by Mr. Darwin, 25 were peculiar, though bearing a strong resemblance to American types; some (the *Orpheus* and the *Geospizinæ*) were even confined to particular islands. But on this comparatively recent volcanic group, only 500 miles distant from the coast of America, everything is exclusively its own—birds, plants, reptiles, and fishes; and though under the equator, none have brilliant colours.

The coasts of Peru and Northern Chile, from their desert nature, are not rich in land-birds, but in southern Chile there are several species of humming-birds, parrots, flamingoes, peculiar ducks and geese; and there commences that inconceivable quantity of sea-birds that swarm on the seas and coasts of the Antarctic regions. The black shearwater, or *Rhynchops nigra*, in its flights has been seen to form a dense mass seven miles long; a particular species of cormorant flies in flocks that form an unbroken line for miles. Pelicans, terns, petrels, &c. &c., cover the low islands and coasts of the mainland, and those of Tierra del Fuego.

In the Antarctic and Southern seas petrels take the place which gulls occupy in our northern latitudes, and inhabit the high southern ones in prodigious numbers. Two remarkable species of this genus are found throughout the Southern Ocean on both sides of Cape Horn—the Giant Petrel (*P. gigantea*), equal to the Albatross in size, and resembling it in its mode of life—it sometimes becomes perfectly white; and the Equinoctial Petrel (*P. æquinoctialis*), a beautiful bird as large as our domestic fowl, and of a jet-black colour. A flock of what was supposed to be the young of the Petrel Pintado, or Cape Pigeon (*P. capensis*), seen during the expedition of Sir James Ross, was estimated to have been from six to ten miles long, and two or three miles broad, absolutely darkening the air during the two or three hours they were flying over the ships. The snowy petrel, a most elegant bird, never quits the ice, and consequently is seldom seen outside of the Antarctic circle. Four species of the Southern Penguins (*Aptenodytes*) inhabit these seas; the *A. Forsteri*, the largest of sea birds, a rare and, for the most part, solitary species, lives on the pack-ice, weighing from 60 to 70 pounds. Two other species of this genus are smaller and gregarious; they crowd in myriads the snow-clad islands in the high southern latitudes; every ledge of rock swarms with them, and on the shore of Possession Island, close to Victoria Land, it is difficult to pass through this feathered multitude. They are fine, bold birds, pecking and snapping with their sharp bills at those who venture to approach them. They can scarcely walk, and, their wings being mere flappers, they cannot fly; from the position of their legs they can stand erect on land, whilst they skim along the sea, and swim with great rapidity, even under water, resembling more a fish or a seal than a bird in their movements. Two species of albatross breed in the Antarctic islands; and a kind of skua gull, which robs their nests; also a goose which, like the eider-duck, lines its nest with the down plucked from its breast. A very curious bird, forming a kind of link between the gallinaceous birds and waders, the Chionis, or Sheath-bill, is only found near the southern extremity of the American continent: it is of a milky white, of the size of our domestic pigeon, and often takes refuge on the yards and rigging of ships off Cape Horn and Staten Land, where it lives chiefly on a small species of cuttle-fish. Few land-birds are met with within the Antarctic circle: there are but seven or eight in the Auckland Islands, mostly species common to New Zealand; among others, the Tooa or Tui, and an olive-coloured creeper, the choristers of the woods. One land-bird only was met with in Campbell Island.

AUSTRALIAN BIRDS.

§ 8. The birds of Australia are in many respects as peculiar as the quadrupeds and plants of that continent; a white falcon is among its birds of prey, a black swan among its water-fowl, and nearly 80 genera of other birds are entirely Australian. The Passeres are so peculiar that they have furnished many new genera. The Bower-bird (so called from the habit the male bird has of building bowers for playing-places), the Regent Oriole, or Sericulus, of splendid black and yellow plumage, and a great proportion of the varied family of Honey-eaters, are essentially Australian. Two species of *Menura*, or Lyre-bird, so called from the resemblance its outspread tail bears to the form of the ancient lyre, are the only birds of the genus, and approach the character of the gallinaceous family. Here are many new forms of cuckoos, as the Coucal and the Scythrops. Of woodpeckers there are none. The parrots, parakeets, and cockatoos are all characteristic, especially the black cockatoo, which is found in Australia only; it is not so gregarious, but even more suspicious than the white cockatoos, which plant a sentinel to warn them of danger. Pigeons and doves abound; the black swan and the Cereopsis goose are no less peculiar among the web-footed tribe. The desert plains of this great continent are inhabited by the Emu, a large struthious bird, incapable of flight, like its congener the Cassowary, and once very plentiful, but now in progress of being extirpated or driven by the rapidly-extending colonists to the unexplored regions of the interior.

Two, if not more, species of the Apteryx, birds of the same family, still linger in New Zealand, but are on the verge of extinction; they probably owe their preservation to their nocturnal habits. This anomalous genus partakes in its zoological characters of several others: the head is something like that of the curlew, with a long, slender bill, fitted for digging into the ground for worms and grubs; the legs and feet resemble those of the common fowl, with a fourth toe like a spur behind; and the wings, if wings they can be called, are exceedingly small. In a specimen whose body measured 19 inches, the wings, stripped of the feathers, were only an inch and a half, ending in a hard horny claw three inches long. These comparatively small wings are characteristic of the whole family; the Ostrich and Rhea have the largest, which, though unavailing in flight, materially aid their progress in running by serving as a kind of sail; the wings of the Emu and Apteryx are only instruments of defence: the whole tribe also defend themselves by kicking. No animals have a more remarkable geographical distribution than this family, or show more distinctly the decided limits within which they have originally been placed. These huge birds can neither fly nor swim, consequently they could not have passed through the air or the ocean to distant continents and islands. They form five distinct genera, to each of which very extensive and widely-separated countries have been allotted: the Ostrich is spread over Africa, from the Cape of Good Hope to the deserts of Arabia; two species of the Rhea range over the Pampas, the plains of Patagonia, and the elevated valleys of Southern Bolivia and Peru; the continent of Australia is the abode of the Emu; the Cassowaries rove over some of the large islands of the Melanesian Archipelago; and the Apteryx, as stated above, dwells exclusively in New Zealand. The Dodo, a very large, short-winged bird, extirpated within the memory of man, inhabited the island of Mauritius. Recent observations of its skeleton have led some naturalists to think it akin to the Trerons, or fruit-eating pigeons. The Solitaire, another species, also allied to the pigeons, lived on the island of Rodriguez, one of the Mascarene group, at no remote period; the Isle of Bourbon was inhabited by two other species, all of which have become extinct; and in the island of Madagascar a bird, exceeding in size all now living, appears to have existed at a very recent period, shells of its eggs, of ten times the capacity of those of the living ostrich, having been of late years discovered in what appears to be a very modern alluvial deposit. This bird, to which the name of *Epyornis* has been given, was one of the giants of the feathered race, living or extinct.

The remains of a very numerous group of extinct struthious birds have been discovered imbedded in the very recent deposits of New Zealand. One of its genera, the Dinornis, chiefly found in the north island, consists of several species: the largest, the D. giganteus, attained a height of 11 feet, or double that of the tallest ostrich; another, the Palapteryx, almost peculiar to the Middle Island, was upwards of 9 feet in height. From the geological position in which these bones are found, as well as from their state of preservation, they can scarcely be considered as fossil, although belonging to species which have become extinct. Professor Owen has described no less than six species of Dinornis, and four of Palapteryx; and later discoveries in the colony have added several to these numbers. No better example can be cited, as elucidating the certainty of the deductions of the comparative anatomist, than what led to the first discovery of this extraordinary group of birds. A small portion of a bone, which from its dimensions appeared to belong rather to a quadruped the size of an ox than to a bird, was submitted to Mr. Owen; he boldly pronounced it, from its structure, to belong to a bird, and of the ostrich kind—a determination that was soon abundantly confirmed by the discovery, not only of the bones of the bird, but of its eggs.

The bones of another extinct bird, perhaps a Nestor, have been found mixed with those of the Dinornis. There are three species of the Nestor; two in New Zealand; another, almost extinct, in Philip Island, only five miles in extent, is found in no other part of the world. They are allied to the curious living genus Strigops, something between an owl and a parrot, but more nearly allied to the latter, and very remarkable for its nocturnal habits and for living in burrows, which it makes at the roots of the fern-trees. The Notornis, a genus supposed to have been extinct, closely allied to the water-hen, the size of a bustard, has also its ancient representative in these islands,[1] where birds did and do exist, almost to the entire exclusion of quadrupeds and reptiles: an extinct species of dog, and a still existing rat, are the only animals of the class of mammalia which shared these extensive territories with multitudes of the feathered race.[2]

The ostrich family live on vegetables; the form of those that had their home in New Zealand would lead to the conclusion that they had fed on the roots of the edible fern which abounds in that country; and as no quadruped excepting a rat is now indigenous these birds could have had no enemy but man, the most formidable of all.

The beautiful and sprightly Tui, or parson-bird, native in New

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[1] The Notornis has been found living in the Middle Island, at Dusky Bay. Its nearest affinity is with the genus Porphyrio of the Old World.

[2] In some parts of the earth the same conditions which regulated the distribution of the ancient fauna and flora still prevail. The flora of the carboniferous epoch reminds us of that of New Zealand, where ferns and club-mosses are so abundant; and the fauna of that ancient period had been representative of that which recently prevailed in these islands, since footprints of colossal birds have been discovered in the red sandstone of Connecticut.

The age of reptiles of the Wealden and other secondary periods is representative of the fauna of the Galapagos islands, which chiefly consists of tortoises and creatures of the lizard or crocodile family; and the cycadaceous plants and marsupial animals of the oolite are representative of the flora and fauna of Australia.

The colossal birds which existed in New Zealand, almost to the entire exclusion of reptiles and quadrupeds, lasted to a very recent period.

Zealand, is jet-black with a white tuft on its breast, and so imitative that it can be taught to repeat whole sentences. There are parrots and parakeets, vast numbers of pigeons, fine warblers, many small birds, and a great variety of waterfowl, amongst others a cormorant, which, though web-footed, perches on the trees that overhang the streams and sea, watching for fish; and a frigate-bird, that pounces on them from a great height in the air. Altogether there are more than 100 species of birds that inhabit this group of islands.

CHAPTER XXXIV.

DISTRIBUTION OF MAMMALIA.

§ 1. Distribution of the several orders of mammalia over the globe; migration of animals due to instinct; animals of the north of Europe, Asia, and Africa, common in species. § 2. European quadrupeds; changes effected in animals through civilization; wild quadrupeds of Europe; some animals limited to certain elevations, others circumscribed in locality. § 3. Asiatic quadrupeds; prevalence of both wild and domesticated animals in Asia; Asia Minor a district of transition; fauna of Arabia and the table-lands and mountains of Eastern Asia; ruminants in Asia more numerous than in other parts of the world; oxen domesticated in India from time immemorial; camels; antelopes; deer; pachydermata; carnivora; edentata; peculiarity of the fauna of the Indian Archipelago; the ape and monkey tribe; two-horned rhinoceros of Java; anoa; marsupials, &c. § 4. African quadrupeds; their nature and distribution affected by the opposite extremes of aridity and moisture on the continent; fauna chiefly differ from other parts of the world; ruminants very numerous; Africa the land of the antelope genus; rodents; peculiar species of the horse; elephants; apes; great variety in the species of the cat tribe; foxes; edentata, &c.; fauna of Madagascar. § 5. American quadrupeds; domestic animals and civilized inhabitants of the continent derived from Europe; fur-bearing animals of Arctic America; usefulness of American dogs; ruminants; rodents; fauna of N. and S. America separated by the high land of Mexico; multitudes of the monkey tribe; opossums; their characteristics; peculiarity of the edentata; native dread of the vampire bat; paucity of the ruminants prior to the conquest of S. America; the alpaca, vicuña, and guanaco; rodentia; relation of animals to vegetation; fauna of the West Indies. § 6. Australian quadrupeds; numbers of the marsupials; peculiarities of the rodentia; analogy between the fauna of Australia and S. America.

§ 1. THE Mammalia, exclusive of man, consist of ten orders of animals, which, however differing in appearance, agree in the one general character of suckling their young. These orders are—the Quadrumana, animals which can use their fore and hind feet as hands, as monkeys and apes; Cheiroptera, animals with winged arms, as bats; Carnivora, that live on animal food, as the lion, tiger, bear, &c.; Rodentia, or gnawers, as beavers, squirrels, mice;

Edentata, or toothless animals,[1] as sloths, anteaters, and armadilloes; Pachydermata, or thick-skinned animals, as the elephant, the horse, hippopotamus, and hog: Ruminantia, animals that chew the cud, as camels, lamas, giraffes, cows, sheep, deer; Marsupialia, possessing a pouch into which the young, born in a less perfect state than in the other families, is received after birth; Monotremata, mammals of low organization allied to marsupials; and Cetacea, inhabiting the waters, as dolphins, cachalots, whales, manati, &c.

The animal creation, like the vegetable, varies with height above the sea, and latitude; the changes of species in ascending the Himalaya, for instance, are similar to what a traveller would meet with in his journey from an equatorial to a high latitude. The number of land mammals increases from the frigid zones to the equator, but the law is reversed with regard to the marine mammalia, which abound most in high latitudes.

Taking a broad view of the distribution of the ten orders of mammalia, it may be stated that the tropical forests are the chief abode of the monkey tribe. Asia is the home of the ape, especially the islands of the Indian Archipelago, as far as the most easterly meridian of Timor, beyond which there are none: they abound throughout Africa from the Cape of Good Hope to Gibraltar, where the Barbary ape is found, the only place where it is met with in Europe: another species of ape inhabits the island of Niphon, the northern limit of monkeys at the eastern extremity of the old continent; Madagascar is the chief home of the Lemurs, which are monkeys of lower organization. No Quadrumana are found in Australia, with New Zealand, New Guinea, and neighbouring islands E. of Celebes, in Oceania, Northern Asia, or extratropical America.

The bats that live on fruits, forming a distinct section of the order, are met with in tropical and warm climates of the Old World, especially in the Indian Archipelago; the common bats which live on insects, and are so numerous in species as to form the principal portion of the whole family, are found everywhere except in arctic America; they are the only indigenous mammals found in remote islands, such as New Zealand. The vampire is only met with in tropical America.

Carnivorous mammalia are distributed all over the globe, though very unequally: in Australia there are no true Carnivora; while in the tropical regions of America there are about 120, in Africa 150, and in Asia 180 species; and so rapid is their increase towards the tropical regions, that there are nearly three times as many in the tropical as in the temperate zones.

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[1] Or more properly wanting certain teeth, as the canines or incisors.

With regard to the Gnawers or Rodentia, species of the same group frequently have a wide range in the same, or nearly the same, parallels of latitude, but when they are inhabitants of high mountain-ridges they follow the direction of the chain, whatever that may be, and groups confined to high latitudes often appear again at great elevations in lower ones. The Edentata are more particularly characteristic of South America, where there are three times as many species as there are elsewhere. The Pachydermata are very abundant in the old continent; they have been introduced into North America by man; in the southern part of that continent the only indigenous kinds are the tapir and various species of peccary. The Ruminantia abound all over the temperate and tropical countries of both continents, and three species are found as far as beyond the Arctic Circle—there are neither Ruminantia nor Pachydermata in Australia. The Marsupialia are confined to it and New Guinea, with a few species in the two Americas. The Monotremata, a singular class of quadrupeds possessing many of the attributes of birds with those of the marsupialia, belong exclusively to the Australian continent.

The distribution of mammalia is governed by laws analogous to those which regulate that of plants, insects, fishes, and birds. Each continent, and even different parts of the same continent, are centres of zoological families, and the exclusive home of many distinct species and genera.

Food, security, and temperature have little influence as primary causes in the distribution of animals. The plains of America are not less fit for rearing oxen than the meadows of Europe; yet the common ox was not found in that continent at the time of its discovery; and with regard to temperature this animal thrives on the Llanos of Venezuela and the Pampas of Buenos Ayres as well as on the steppes in Europe. The horse is another example: originally a native of the deserts of Tartary, he now roams wild in herds of hundreds of thousands on the grassy plains of America, though unknown in that continent at the time of the Spanish conquest.[1] All animals, however, are not so flexible in their constitutions, for most of them would perish from change of climate. The stations which the different genera and species now inhabit must have been occupied by them as each part of the land rose above the ocean, the occupation depending on the propinquity of the stations they previously inhabited, and the absence of natural barriers; and because they have found in these stations all that was necessary for their existence many have never wandered from them, notwithstanding their powers of locomotion; while others have migrated, but only within certain bounds.

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[1] There exist, however, remains of many fossil species of horse in several parts of South and North America, contemporaneous with the mastodons and extinct gigantic Edentata of that continent.

Instinct leads animals to migrate when they become too numerous: the rat in Kamtchatka, according to Pennant, sets out in spring in great multitudes, and travels 800 miles, swimming over rivers and lakes; and the Lapland marmot or lemming, a native in the mountains of Kölen, migrates in great numbers, once or twice in 25 years, to the Western Ocean, which they enter and are drowned; other bands go through Swedish Lapland, and perish in the Gulf of Bothnia. Thus nature provides a remedy against the over increase of any one species, and maintains the balance of the whole creation. A temporary migration for food is not uncommon in animals. The wild ass, or Onagra, a native of the deserts of Great Tartary, in summer lives to the E. and N. of the lake of Aral, and in autumn migrates in great numbers to Persia, and even to the high plains of North-Western India.[1] The ruminating animals that dwell in the inaccessible parts of the Himalaya and the Andes descend to their lower declivities in search of food in winter; and for the same reason the reindeer and musk-ox leave the Arctic snows for a more southern latitude.

The Arctic regions form a district common to Europe, Asia, and America. On this account, the animals inhabiting the northern parts of these continents belong to the same species, or to forms very similar; in fact, there is no genus of quadrupeds in the Arctic regions that is not found in the two great continents, though there are only 27 species common to all, and these are mostly fur-bearing animals. In the temperate zones of Europe and Asia, which form an uninterrupted region, identity of species is occasionally met with, but for the most part marked by such varieties in size and colour as might be expected to arise from difference of food and climate. The same genera are sometimes found in the intertropical parts of Asia, Africa, and America, but the same species very rarely, if ever; much less in the southern temperate zones of these continents, where nearly all the animals are different, whether birds, beasts, insects, or reptiles; but in similar climates tribes of forms in many respects analogous replace one another.

Europe has no family and no order peculiarly its own, and many of its species are common to other countries; consequently the great zoological districts, when the subject is viewed on a broad scale, are Northern Europe and Siberia, Southern Asia, Africa, North and South America, and Australia; but in each of these there are smaller districts, to which particular genera and families are confined. Yet when regions of similar climate and vegetation are not separated by lofty mountain-chains, or other great barriers, the faunas are in most cases blended together on the confines between the two districts, so that there is not a sudden change.

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[1] The wild ass is frequent in the plains of Sindh and Beloochistan, where it is known by the name of Gorkhar. There is some doubt as to its being the same species as the Kiang of the mountainous regions of the Himalaya and Tibet, where the latter has been seen as high as 18,600 feet above the level of the sea.

EUROPEAN QUADRUPEDS.

§ 2. The character of the animals of temperate Europe has been more changed by the progress of civilization than that of any other quarter of the globe. Many of its original inhabitants have been extirpated, and new races introduced; but it seems always to have possessed various animals capable of being domesticated. The wild cattle in the parks at Hamilton and in that of the Earl of Tankerville are the only remnants of the ancient inhabitants of the British forests, though they were spread over Europe, and perhaps were the parent stock from which the European cattle of the present time are descended; the Aurochs (Urus), an animal nearly extinct, and found only in the forests of Lithuania, represents the Bison of North America, and is untameable. Both are supposed to have come originally from Asia. The mouflon, which exists in Corsica and Sardinia, is by some supposed to be the parent stock of our domestic sheep. The hog, the goat, the red and fallow deer have been domesticated, and also the reindeer, which cannot strictly be called European, since it also inhabits the northern regions of Asia and America. Our domestic cat is an European species in its wild state. Altogether eight or ten species of our domestic quadrupeds have sprung from native animals.

A remarkable uniformity prevails in the organization and instincts of each species of animal in its wild state. Many adapt themselves to change of climate; after some generations their habits and organization alter to suit the new condition in which they are placed; but domestication is the cause of all our tame and useful animals; by high cultivation and training great changes have been produced in form; and in some instances habits and powers of perception are produced, approaching to reason, which remain hereditary as long as the breed is unchanged.

There are still abont 180 wild quadrupeds in Europe: 45 of these are also found in western Asia, and nine are common to northern Africa. The most remarkable are the reindeer, elk, red and fallow deer, the roebuck, glutton, lynx, polecat, some species of wild cats, the common and black squirrels, the fox, wild boar, wolf, the black and the brown bear, several species of weasels and rodents. The otter is common, but the beaver is now met with only on the Rhine, the Rhone, the Danube, and some other large rivers; rabbits and hares are numerous; the hedgehog is very generally distributed; the porcupine in southern Europe only; the chamois and the ibex, or bouquetin, in the Alps and Pyrenees. Many species of these animals are widely distributed over Europe, generally with variations in size and colour. The chamois of the Alps and Pyrenees, though of the same species, is slightly changed in appearance; the fox of the most northern parts of Europe is larger than that of Italy and of the S., with a thicker fur, and of somewhat different colour, depending on climate.

Some animals never descend below a certain height, as the ibex and chamois, which live at greater elevations than any of our European quadrupeds, being usually found between the region of trees and the line of perpetual snow, which is about 8900 feet on the southern, and 8200 on the northern declivities of the Alps. The red deer does not ascend beyond 7000 feet, and the fallow-deer not higher than 6000, above the level of the sea: the two latter, however, descend to the plains, the former never do. The bear, the lynx, and the stoat are sometimes met with nearly at the limit of perpetual snow.

Some European animals are much circumscribed in their localities. The mouflon is confined to Corsica and Sardinia; a species of weasel and bat inhabit Sardinia only; and Sicily has several bats and mice peculiar to it. There is only one species of monkey in Europe, which lives on the rock of Gibraltar, and is supposed to have been introduced from Africa. All the indigenous British quadrupeds now existing, together with extinct hyæna, tiger, bear, and wolf, whose bones have been found in caverns, are also found in the same state in Germany. Ireland was probably separated by St. George's Channel from England before all the animals had migrated to the latter; so that our squirrel, mole, pole-cat, dormouse, and several smaller quadrupeds, never reached the sister island. Professor Owen has shown that the British horse, ass, hog, the smaller wild ox, the goat, roe, red deer, beaver, with many small rodents, are the same species with those which had co-existed with the mammoth or fossil elephant, the great northern hippopotamus, and two kinds of rhinoceros long extinct; so that a part only of the modern tertiary fauna has perished, from whence he infers that the cause of their destruction was not a violent universal catastrophe from which none could have escaped. The Bos longifrons and the gigantic Elk of the Irish bogs, now an extinct species, and also, according to the evidence of flint weapons in drift deposits, the Mammoth, hairy Rhinoceros, and other large animals, were probably co-existent with man.

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ASIATIC QUAD

§ 3. Asia has a greater number an
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white squirrel; and even the Bengal royal tiger is sometimes seen on Mount Ararat, and is not uncommon in Azerbijan and the mountains of Persia.

Arabia is inhabited by the hyæna, panther, jackal, and wolf. Antelopes and monkeys are found in Yeman. Most of these are also indigenous in Persia. The wild ass, or Onagra, the Gorkhar of North-west India, a handsome spirited animal of great speed, and so shy that it is scarcely possible to approach it, wanders in herds over the plains and table-lands of Central Asia, extending its migrations as far as the plains of Beloochistan and Sindh, to the Indian desert, and to the Runn of Kutch—"the wilderness and the barren lands are his dwelling." There is a distinct species (the Kiang) that lives in the most elevated regions of Tartary and Tibet; it has been seen on the shores of the sacred lakes of Manasarowar and Rakasthal, at a height of more than 15,250 feet above the sea, and on one occasion as high as 18,600.

A few animals are peculiar to the high cold plains of the table-land of eastern Asia: the Dziggetai, a very fleet animal, is peculiar to these Tartarian steppes. Two species of antelopes inhabit the plains of Tibet, congregating in immense herds, with sentinels so vigilant that it is scarcely possible to approach them.

The Dzeran, or yellow goat, which is both swift and shy, and the handsome Tartar ox, are natives of these wilds; also the shawl-wool goat and the Manul, from which the Angora cat, so much admired in Persia and Europe, is descended. Many of the animals that live at such heights cannot exist in less elevated and warmer regions, exhibiting an instance of the limited distribution of species. Goats and sheep endure best the rarefied air and great cold of high lands: the Cashmere goat and Argali sheep browse on the plains of Tibet at elevations of from 10,000 to 13,000 feet; the Rass, a sheep with spiral horns, lives on the table-lands of Pamir, which are 15,000 feet above the sea; and also the Kutch-gar, a species of sheep which is about the height of a year-old colt, with fine curling horns: they congregate in flocks of many hundreds, and are hunted by the nomade tribes of Kirghis.

The ruminating animals of Asia are more numerous than those of any other part of the world: 64 species are native, and 46 of these exist there only. There are several varieties of wild oxen; one in the Birmese empire, and on the mountains of north-eastern India, with spiral twisted horns. The buffalo is a native of China, India, Borneo, and the Sunda Islands; it is a large animal, formidable in a wild state, but domesticated throughout the East. It was introduced into Italy in the sixth century, and large herds now graze in the low marshy plains near the sea.

Various kinds of oxen have been domesticated in India from time immemorial; the Zebu or India ox, with a hump on the shoulders, has been venerated by the Brahmins for ages. The Yak, a beautiful animal, which is chiefly employed as a beast of burthen by the Tibetans, has long been domesticated, and can live on the passes of the Himalaya as high as 19,300 feet. Its white silky tail, used in the East to drive away flies, has been adopted as the Turkish standard; and the common Indian ox differs from all others in the great speed of its course. Some other species of cattle have been tamed, and some are still wild in India, Java, and other Asiatic islands. The Cashmere goat, which produces the shawl-wool, is the most valuable of the several varieties of goats and sheep of Asia; it is kept in large herds in the great valleys on the northern and southern declivities of the Himalaya, and in the upper regions of Bhotan, where the cold climate is congenial to it.

The Bactrian camel, with two humps, is strong, rough, and hairy, and is said to be found in a wild state in the desert of Shamo: it is the camel of central Asia, N. of the Himalaya and Taurus, also of the Crimea and the countries round the Caucasus. The more common or Arabian species, the Dromedary, with one hump, is a native of Asia, though only known now in a domesticated state: it has been introduced into Africa, Italy, the Canary Islands, and even into the elevated regions of the Peru-Bolivian Andes. The best come from the province of Nejed in Arabia, which on that account is called the "mother of camels." The camel of Oman is remarkable for beauty and swiftness.

Ten species of antelopes and twenty of deer are peculiar to Asia: two species of antelopes have already been mentioned as peculiar to the table-lands, the others are distributed over the islands of the Asiatic archipelago. The musk-deer (*Moschus moschiferus*) inhabits the mountainous countries of central and south-eastern Asia, between China and Tartary, the regions round lake Baikal, the Altaï mountains, Nepaul, Bhotan, Tibet, and the adjacent country of China.

Asia possesses about ten species of Pachydermata, including the elephant, horse, ass, which have been domesticated from the time of the earliest historical records. The horse is supposed to have existed wild in the plains of central Asia, as the dromedary in Arabia, though now they are only known as domestic animals. The Arabian and Persian horses possess acknowledged excellence and beauty, and from these our best European breeds are descended; the African horse, which was introduced into Spain by the Moors, is probably of the same race.

The elephant has long been a domestic animal in Asia, though it still roams wild in formidable herds through the forests and jungles at the foot of the Himalaya, in other parts of India, the Indo-

Chinese peninsula, and the islands of Sumatra and Ceylon; the hunting elephant is esteemed the most noble. A one-horned rhinoceros is a native of continental Asia.

There are several genera of Asiatic carnivorous animals, of which the royal tiger is the most beautiful and formidable; its favourite habitation is in the jungles of Hindostan, though it wanders nearly to the limit of perpetual snow in the Himalaya, to the Persian and Armenian mountains, to Siberia and China. Leopards and panthers are common, and there is a maneless variety of the lion in Guzerat; the cheetah, used in hunting, is the only one of the leopards capable of being tamed. The hyæna is found everywhere, excepting in the Birmese empire, in which there are neither wolves, hyænas, foxes, nor jackals. There are four species of bears in India; that of Nepaul is said to furnish a valuable fur: the wild boar, hog, and dogs of endless variety, abound all over the continent.

The edentata have only two representatives in India, which differ from all others except the African in being covered with imbricated scales. Of these the short-tailed Pangolin, or scaly ant-eater, is found throughout the Deccan, Bengal, Nepaul, the southern provinces of China, and in the island of Formosa.

The Indian Archipelago and the Indo-Chinese peninsula form a zoological sub-province, having several animals exclusively its own. The royal tiger abounds in the peninsula of Malacca, and also the black variety of the panther, leopard, wild cats, multitudes of elephants, the rhinoceros of the three Asiatic species, the Malayan tapir, numerous species of deer, the Babiroussa hog, and another species of that genus. Some groups of the islands have several animals in common, either identical or with slight variations, that are altogether wanting in other islands, which, in their turn, have creatures of their own. Many species are common to the archipelago and the neighbouring parts of the continent, or even to China, Bengal, Hindostan, and Ceylon. Flying quadrupeds are a distinguishing feature of this archipelago, though some do not absolutely fly, but by an extension of the skin of their sides to their legs, which serves as a parachute, are enabled to take long leaps and to support themselves in the air. Nocturnal flying squirrels, of several species, are common to the Malayan peninsula and the Sunda Islands, especially Java; and three species of flying lemurs inhabit Sunda, Malacca, and the Pelew Islands. Besides these, there are the frugivorous bats, which really do fly, differing from bats in other countries by living exclusively upon vegetable food. The Roussette, or Kalong, which is used as an article of food, one of the largest known, appears in flocks of hundreds, and even thousands, in Java, Sumatra, and Banda: the Pteropus funereus, another of these large bats, assembles in as great numbers.

About 180 species of the ape and monkey tribe are entirely Asiatic: monkeys are found only on the coast of India, Cochin-China, and the Sunda Islands: the long-armed apes or Gibbons belong to the Sunda Islands and the peninsula of Malacca. The Simayang, a very large ape of Sumatra, moves about in large troops, following a leader, and makes a howling noise at sunrise and sunset that is heard miles off. Sumatra and Borneo are the peculiar abode of the Orang-outang, a name which in the Malay language signifies "man of the woods;" except perhaps the Chimpanzee of Africa, it approaches nearest to man. It has never spread over the islands it inhabits, though there seems to be nothing to prevent it, but it finds all that is necessary within a limited district. The orang-outang and the long-armed apes have extraordinary muscular strength, they swing from tree to tree by their arms.

The Malays have given the name of orang, or man, to the whole tribe, on account of their intelligence as well as their form.

A two-horned rhinoceros is peculiar to Sumatra, of a different species from the African, also the Felis macrocelis, and a very large bear; there are only two species of squirrels in Java, which is remarkable, as the Sunda Islands abound in them. The royal tiger of India and the elephant are found in Sumatra, and the Babiroussa hog in Borneo; but these two islands possess many quadrupeds in common, as a leopard, the black antelope, some graceful miniature creatures of the deer kind, the tapir, also found in Malacca, besides a wild bear, an inhabitant of all the marshy forests from Borneo to the Moluccas. In the larger islands deer abound, some as large as the elk, probably the Hippelaphus of Aristotle.

The Anoa, a ruminating animal about the size of a sheep, a species of antelope, shy and savage, goes in herds in the mountains of Celebes, where many animals strangers to the Sunda Islands, begin to show themselves, as some sorts of phalangers, or pouched quadrupeds. These new forms become more numerous in the Moluccas, which are inhabited by flying phalangers and other pouched animals, with hairless scaly tails. The phalangers are nocturnal, and live on trees. In New Guinea there are kangaroos, the spotted phalanger, the New Guinea hog, and the Papua dog, said to be the wild species from which all the native dogs in Australia and Oceania, wild or tame, are descended. The eastern islands of the Archipelago, in fact, belong to a zoological division quite distinct from Southern Asia, and according to Mr. Wallace, our latest and best authority, should be classed with Australia. The line of division is a deep-sea channel running nearly S.E. and N.W. through the islands, beginning with the narrow strait which separates the islands of Bali and Lombok and running between Borneo and Celebes. Celebes is to some extent an intermediate land, possessing a representative of the Quadrumana order. In all the other eastern islands, as in Australia, monkeys, pachydermata, and a host of other families, genera and species common in the Western islands and Southern Asia, are entirely unknown. It is remarkable that this classification corresponds with the depth of the seas separating the lands; Borneo, Sumatra, and Java, being connected with the Malayan Peninsula by a shallow sea, just as New Guinea and its surrounding islands are connected by a channel of small depth with Australia.

AFRICAN QUADRUPEDS.

§ 4. The opposite extremes of aridity and moisture in the African continent have had great influence on the nature and distribution of its animals; and since by far the greater part consists of plains utterly barren or covered by temporary verdure, and watered by periodical streams that flow only during a few months in the year, fleet animals, fitted to live on arid plains, are far more abundant than those that require rich vegetation and much water. The latter are chiefly confined to the intertropical coasts, and especially to the large jungles and deep forests in the centre and at the northern declivity of the table-land, where several genera and many species exist that are not found elsewhere. Africa has a fauna in many respects different from that of every other part of the globe; for although about 100 of its quadrupeds are common to other countries, there are 250 species exclusively its own. Several of these animals, especially the larger kinds, are distributed over the whole table-land from the Cape of Good Hope to the highlands of Abyssinia and Senegambia without the smallest variety, some are slightly modified in colour and size. Ruminating animals are very numerous, though few have been domesticated: of these the ox of Abyssinia and Bornou is remarkable from the extraordinary size of its horns, which are sometimes two feet in circumference at the root; the Galla ox of Abyssinia has horns four feet long; and the ox from Kuruman, in the territory of our Cape Colony, five feet in length, by one and three-quarters in diameter at the base. There are many African varieties of buffalo; that at the Cape of Good Hope is a large, fierce animal, wandering in herds in every part of the country, even to Abyssinia: the flesh is sometimes impregnated with the odour of musk. The African sheep and goats, of which there are many varieties, differ from those of other countries; the wool of all is coarse, except that of the Merino sheep, said to have been introduced from Morocco into Spain by the Moors.

No country possesses a ruminating animal similar to the Giraffe, or Camelopard, which ranges widely over South Africa from the northern banks of the Gareep, or Orange river, to the Great Desert; it is also found in Dongola and in Abyssinia. It is a gentle timid animal, and has been seen, though rarely, in troops of 100. The earliest record we have of it is on the sculptured monuments of the ancient Egyptians, and it is well known that it was brought to Rome to grace the triumph of a victorious emperor.

Africa may truly be called the land of the genus *Antilope*, which is found in every part of it, where it may be said to represent the deer of Europe, Asia, and America. Different species have their peculiar localities, while others are more widely dispersed. The greater number are inhabitants of the open plains, while a few penetrate into the forests. About 70 species have been described, of which at least 26 are found N. of the colony of the Cape of Good Hope and in the adjacent countries. They are of every size, from the pigmy antelope, not larger than a hare, to the Caama and the Eland, which are as large as the ox and horse. Timidity is the universal character of the race. Most of the species are gregarious; and the number in a herd is far too great even to guess at. Like all animals that feed in herds, they have sentinels; and they are the easy prey of so many carnivorous animals, that their safety requires this precaution. At the head of their enemies is the lion, who lurks among the tall reeds at the fountains, to seize them when they come to drink. The antelopes for the most part are graceful in their motions, especially the Springbuck, which travels in compact troops; and in their march there is constantly one which gathers its slender limbs together, and bounds into the air.

Africa has only two species of deer, both inhabiting the chain of the Atlas: one is the common fallow-deer of Europe.

There are three species of the horse peculiar to South Africa; of these the Zebra, the more sober-coloured Quagga, and Burchell's Quagga, beautifully striped, wander in troops over the plains, often in company with ostriches. An alliance between creatures differing in nature and habits is not easily accounted for. The two-horned rhinoceros of Africa is different from that of Asia; there are certainly three, and probably five, species of these huge animals peculiar to the table-land. Dr. Smith saw 150 in one day near the 24th parallel of S. latitude. The hippopotamus is exclusively African: multitudes inhabit the lakes and rivers in the tropical and southern parts of the continent; those that inhabit the Nile and Senegal, if they do not belong to a different species, form a very marked variety. The elephant differs very considerably from that of Asia, and is so numerous that 200 have been seen in a herd near lake Chad: and according to the accounts of recent explorers they seem to be equally numerous in other parts of the interior of the continent. They are not domesticated in Africa, and are hunted by the natives for their tusks. The Phacochœrus, or Wart-hog, lives beyond the limits of Cape colony; and the Bosch Vark (*Sus larvatus*), on its eastern coasts, as well as a species of Hyrax, are among the peculiar Pachydermata of this continent. The monkey tribe is found in all the hot parts of Africa: peculiar genera are allotted to particular districts. Except a few in Asia, the group of the Guenon monkeys is found in no other part of the world than about the Cape of Good Hope, and on or near the coasts of Loanda and Guinea. The species are numerous, and vary much in size and colours; the Cynocephalus, or dog-headed baboon, with a face like that of a dog, is large, powerful, and dangerous. A species of these baboons inhabits Guinea, others the southern parts of the tableland, and one is met with everywhere from Sennaar to Caffraria. A remarkable long-haired species of baboon, the Hamadryas, is found in the mountains of Abyssinia, 8000 feet above the sea; the Mandrills, which belong to the same genus, come from the coasts of Guinea. The magot, or Barbary ape, is common over Northern Africa. The African long-haired tailless apes, which form the genus Colobus, are met with in the tropical districts on the western coast; the C. Polycomos, or king of the monkeys, so called by the natives from its beautiful fur and singular head of bushy hair, is met with in the forests about Sierra Leone. The Chimpanzee, which so nearly approaches the human form, inhabits the forests of Western Africa from Cape Negro to the Gambia. Living in troops, like most apes and monkeys, which are eminently gregarious, it is very intelligent and easily tamed. A new genus, the Gorilla, allied to the Chimpanzee, surpassing in size the Orang-outang, was first accurately described by Professor Owen: its habitat is restricted to the equatorial coast forests around the Gaboon and Fernand Vaz rivers. Other species or varieties of the Chimpanzee were added by the indefatigable explorer M. du Chaillu.[1]

Africa possesses the cat tribe in great variety and beauty; lions, leopards, and panthers are numerous throughout the continent; servals and viverrine cats inhabit the torrid districts; and the lion of the Atlas has ever been considered the most formidable of carnivorous animals. In no country are foxes so abundant. Various species inhabit Nubia, Abyssinia; and about the Cape of Good Hope we find the lion, leopard, and the serval. A long-eared fox of nocturnal habits, the Fennec of Bruce, found from the Cape of Good Hope to Kordofan, is peculiar to Africa. There are also various species of dogs, the hyæna, and the jackal. The hyænas hunt in packs, attack the lion and panther, and end by destroying them.

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[1] 'Adventures in Equatorial Africa,' 1861.

Two genera of Edentata are African—the long-tailed Manis of several species, and the Aard-vark, or earth-hog; the first is covered with horny scales, the latter with coarse long hair; they burrow in the ground and feed on ants. Great flocks of a large migratory frugivorous bat frequent the Slave-coast.

Multitudes of antelopes of various species, lions, leopards, panthers, hyænas, jackals, and some other carnivora, live in the oases of the great northern deserts; jerboas, and endless species of rats, mice, and other small rodents, burrow in the ground. The dryness of the climate and soil keeps the coats of the animals clean and glossy; and it has been observed that tawny and grey tints are the prevailing colours in the fauna of the North African deserts, not only in the birds and beasts, but in reptiles and insects. In consequence of the continuous desert extending from North Africa through Arabia to Persia and India, many identical species of quadrupeds exist in those countries.

The fauna of the great island of Madagascar is in some small degree analogous to that of India, though, as far as it is known, it seems to form a distinct centre of animal life. It has no ruminating animals, pachyderms or large Felidæ; and the monkey tribe is represented by the Lemurs, the Galagos, and Indris, animals characteristic of this insular fauna. A frugivorous bat, the size of a common fowl, forms an article of food; and an anomalous animal, the Cheiromys, or Aye-Aye, intermediate between the Lemuridæ amongst the Quadrumana, and the Rodents, has only been found in this island.

AMERICAN QUADRUPEDS.

§ 5. America is probably the richest zoological province in the world, possessing nearly 600 species of mammalia, of which 480 are peculiar to it; yet no country has contributed so little to the stock of domestic animals. With the exception of the llama and alpaca, the turkey, and perhaps some varieties of dogs, America has furnished no quadruped or bird serviceable to man, while it has received from Europe all its domestic animals and its present civilized inhabitants.

Arctic America possesses most of the valuable fur-bearing animals that are found in Siberia; and they were very plentiful till the unsparing destruction of them has driven those yet remaining to the high latitudes, where the hunters that follow them are exposed to great hardships. Nearly 2,000,000 of skins are brought annually to England, most of which are taken in the forest regions. The Barren Grounds are inhabited by the Arctic fox, the polar hare, the brown and the white bear, a formidable animal which generally lives on the ice itself. The reindeer feeds on the lichens and mosses of these barren grounds, and wanders to the shores of the Polar Ocean: its southern limit in Europe is the Baltic Sea, in America the latitude of Quebec. Some of the fur-bearing quadrupeds of these deserts never pass the 65th degree of N. lat.; the greater number live in the northern forests, as the black bear, racoon, badger, the ermine and four or five other members of the weasel tribe, the red fox, the polar and brown lynxes, the beaver, the musquash or musk-rat, of which half a million are killed annually for their fur, and the elk or moose-deer, whose northern range ends where the aspen and willows, its principal food, cease to grow. The grizzly bear, the largest and most ferocious of its kind, inhabits the range of the Rocky Mountains as far S. as Mexico, as well as the western savannahs. The prairie-wolf, the grey fox, the Virginian hare, live in the prairies; the Wapiti, the largest of the deer tribe after the elk, inhabits those on both sides of the Rocky Mountains; and the Prongbuck, an antelope fleeter than the horse, remarkable for its bifurcated horns, roams throughout the western part of the continent, and migrates in winter to California and Mexico. The Musk-Ox and Bison are peculiar to North America. The musk-ox extends its northern migrations to Parry Islands and Banks Land in the Arctic regions, yet it never has been seen in Greenland or on the north-western side of the continent. The bison is met with as far S. as the Arkansas, and roams, in herds of thousands, over the prairies of the Mississippi and on both sides of the Rocky Mountains. It seldom wanders farther N. than the 60th parallel of latitude, the southern limit of the musk-ox. A species of marmot known by the name of the Prairie Dog is everywhere to be met with in the great plains from which it derives its name.

There are at least eight varieties of American dogs, several of which are natives of high northern latitudes. The Lagopus, or Isatis, of Spitzbergen and Greenland, is found over the Arctic regions of America and Asia, and in the Kurile Islands. Dogs are employed to draw sledges in Newfoundland and Canada; and the Esquimaux travel drawn by dogs as the Lapps and the Finns do by reindeer. These dogs are strong and docile; they were mute till they learned to bark from European dogs in our discovery ships.

There are 13 species of ruminating animals in North America, including the bison, the musk-ox of the Arctic regions, the big-horned sheep, and the goat of the Rocky Mountains. The horse, now roaming wild in innumerable herds over the plains of South America, was unknown there till the conquest by the Spaniards. The quadrupeds of the temperate zone are distributed in distinct groups: those of the state of New York, consisting of about 40 species, are different from those of the Arctic regions, and also from those of South Carolina and Georgia; while in Texas another assemblage of species prevails.

There are about 130 species of rodents, or gnawing animals, in North America—rats, mice, squirrels, beavers, &c.—some of which, especially in the N., appear to be identical with those in the high latitudes of Europe and Asia. The genera of very different latitudes are often representatives, but never identical. Squirrels abound in North America; the grey squirrel is very abundant.

About 30 species of the genus Opossum are enumerated as existing in this continent. Of these the Virginian opossum inhabits the whole extent of America from the Canadian lakes to Paraguay, and also the West India Islands, where it is called the Manicou; and two other species of the tribe live in Mexico. There is a porcupine in the United States and Canadian forests which climbs trees; and others of the same genus are found in South America.

The high land of Mexico forms a very decided line of demarcation between the fauna of North and South America; yet some North American animals are met with beyond it, particularly two bears and an otter, which inhabits the continent from the Icy Ocean to beyond Brazil. On the other hand, the Puma, Jaguar, Opossum, Kinkajou, and Peccari, have crossed this barrier, from South America to California and the United States.

In the varied and extensive regions of South America there are several centres of a peculiar mammalian fauna, according as the country is mountainous or level, covered with forest or grass, fertile or desert, but the animals are inferior in size to those of the Old World. The South American quadrupeds are on a smaller scale, more feeble and more gentle; many of them, as the toothless group including the Sloths, are of anomalous and less perfect organization than the rest of the mammalian creation.

The monkey tribe exist in myriads in the forests of tropical America and Brazil; but they are met with in small numbers to the N. of the Isthmus of Darien, and not farther S. than the Rio de la Plata. They differ widely from those in the Old World, being farther removed from the human form; but they are more gentle and lively. Notwithstanding their agility, they are often victims to birds and beasts of prey.

There are two principal groups of American monkeys—the Sapajous, with prehensile tails, by which they suspend themselves and swing from bough to bough; some of these inhabitants of the woods are very noisy, especially the Araguato, a large ape whose howling is heard a mile off. The Howlers are generally very large, and have a wider range than any others of the genus; one species, the *Mycetes rufimanus*, or Beelzebub, ascends the Andes to the height of 11,000 feet. The Cebus, or Weepers, which are frequently brought to Europe, belong also to this family; the genus has a greater number of species than any other monkey of the New World, but a very narrow location to each; they are most abundant in Guiana.

Squirrel-monkeys and Marmosets form the second group of American monkeys. They inhabit the banks of the Orinoco, and the forests of Brazil. The Marmosets are pretty little animals, easily tamed, especially the Midas leonina, not more than seven or eight inches long.

The forests are also inhabited by Opossums, a genus of the marsupial order, who carry their young in pouches; they are somewhat analogous to the race of animals that form the distinguishing feature of the Australian fauna, but of entirely distinct genera and species. Some of these animals are no larger then a rat, and they mostly live on trees. One is aquatic, the Chironectes, resembling a small otter, and appears to be only found in the river Yapock in French Guiana. A species in Surinam carries its young upon its back. All the Opossums and the Chironectes have thumbs on their hind feet, opposable to the toes, so that they can grasp; they are, moreover, distinguished from the Australian marsupials by a long prehensile tail, and by greater agility.

Five genera and about 30 species of the Edentata are characteristic of this continent, and confined to South America; they consist of the several species of sloths; several Armadilloes, the Chlamyphorus, and four or five Myrmecophagæ or Ant-eaters. The animals of these genera have very different habits: the sloths, as their name implies, are the most sluggish of animals; they inhabit the forests from the southern limit of Mexico to Rio de Janeiro, and to the latitude of the region of Palms and Scitamineæ, as high as 3000 feet on the declivities of the Andes. The Armadillo, in its coat of mail, is in perpetual motion, and can outrun a man in speed. They live on the plains of South America, as far S. as Paraguay and the Pampas of Buenos Ayres. The one-banded armadillo rolls itself up like a ball; the nine-banded one is eaten by the natives; the giant armadillo, three feet long, inhabits the forests. Most of these species are nocturnal, and burrow in the earth in the Pampas. The Chlamyphorus is also a burrowing animal, peculiar to the province of Mendoza on the eastern slope of the Chilian Andes; they have the faculty of sitting upright, for which the hinder part of their scaly armour is admirably adapted. The great or maned Ant-eater (*M. Jubata*), larger than a Newfoundland dog in the body, but with shorter legs, defends itself against the jaguar with its powerful claws; it inhabits the swampy savannahs and damp forests from Venezuela to Paraguay, and from the Atlantic to the foot of the Andes; its flesh, like that of some other American animals, has a strong smell of musk. The little Ant-eater (*M. Tamandua*) has a prehensile tail, and lives on trees in the tropical forests, feeding on the larvæ of bees and wasps, honey, and ants. The cat tribe in South America are beautiful in their colours and powerful in strength: the Puma, called the Lion of America, is found in great numbers both in the mountains and the plains. So different are its habits in different places, that in Chile it is timid and flies from a dog; in Peru it is bold, though it rarely attacks the human race. The Jaguar, which inhabits the deep tropical forests, is very abundant, and so ferocious that it will sometimes spring upon Indians in a canoe; it is one of the few South American animals that extend beyond the Isthmus of Panama, being found in California and in the State of Mississippi; it has been seen even as far N. as Canada; offering a remarkable analogy, in its extensive wanderings, with the Royal Tiger of the Old World, which as we have already seen, is often found amidst the mountains and steppes of Central Asia and Siberia.

The only ruminating animals except the deer that existed in South America prior to the conquest were the four species of the genus Auchenia—the Llama, the Alpaca, the Vicuña, and the Guanaco: the first three are exclusively confined to the colder and more elevated regions of the Peruvian Andes; the last has a wider geographical range, extending to the plains of Patagonia, and even to the southernmost extremity of the continent. The Llama inhabits the high valleys of the Peru-Bolivian Andes, its favourite region being in the valley of the lake of Titicaca: it was the only beast of burden possessed by the aborigines; hence we find it domesticated wherever the Incas carried their conquests and civilization, from the equator to beyond the southern tropic. It is still extensively employed by the Indian as a beast of burthen, and its wool, though coarse, is used by the natives for their clothing. Like all domestic animals, it varies in colour: its flesh is dark and disagreeable to the taste.

The Alpaca, or Paco, a gentle and handsome animal, although more closely allied to the llama than any of its congeners, appears to be a distinct species: it lives in still more elevated sites than the llama, its favourite haunts being on the streams descending from the snowy peaks: it is only found in a domestic state; it is reared for its wool, which is extremely fine, silky, and long, and which now bears a high price, from its introduction into some of our finest woollen tissues.[1] The Vicuña is only found in the wild state in the plains on the Andes, as high as 15,000 feet; the wool is much prized for its fineness. This animal has a shrill whistle; it is easily tamed. The Guanaco, by some naturalists considered erroneously as the parent stock of the llama and alpaca, is also only found in the wild state: it extends to 12° S. lat., is very abundant and in large flocks on the Bolivian and Chilian Andes, and has been seen as far S. as the Strait of Magellan. All these animals feed principally on a species of coarse wiry grass called *ichu*.

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[1] The alpaca has been introduced into the colony of New South Wales with great success.

Several species of deer are found in the tropical regions of South America, and a remarkable one, the Cervus Andium, with fragile hair like that of the roebuck of Europe, as high as 11,000 feet in the Andes.

Among the Rodentia, the Agoutis represent our hares in the plains of Patagonia, in Paraguay, &c., and extend as far N. as Guiana. The tribe of the Cavias, or guinea-pigs, are found in Brazil, and some species in the great table-lands of the Peru-Bolivian Andes; the Echimys or prickly rat, is an inhabitant of the banks of the Rio de la Plata and Paraguay; the Vizcacha of the Pampas, a burrowing animal, inhabits the great plains of Buenos Ayres; an animal bearing the same name, but of a very different species, is frequent in the rocky regions of the Andes, as high as 15,000 feet above the sea; and the beautiful Chinchilla, nearly allied to the latter, whose fur is so highly esteemed, inhabits the same regions, at the same great elevations, in the Andes of South Peru, Bolivia, and Chile: the best fur of the chinchilla is collected in the Bolivian province of Potosi, and in the Chilian province of Copiapo. The largest of all the rodentia, the Capybara (Myopotamus), inhabits the banks of the great rivers of tropical America, where its habits resemble, according to some travellers, those of the hippopotamus. The Paca, the next in size, is less aquatic in its habits, and lives in the dense forests of Brazil and Paraguay.

It is very remarkable that, in a country which has the most luxuriant vegetation, there should not be one native species of hollow-horned ruminants, as the ox, sheep, goat, or antelope; and it is still more extraordinary that the existing animals of South America, which are so nearly allied to the extinct inhabitants of the same soil, should be so inferior in size not only to them, but even to the living quadrupeds of South Africa, which is comparatively a desert as regards its vegetation. The quantity of vegetation in Brazil at any one time exceeds the quantity of an equal area in the interior of South Africa very considerably, yet Mr. Darwin has computed that the weight of 10 of the largest South African quadrupeds is 24 times greater than that of the same number of quadrupeds in South America; for in South America there is no animal of the size of a cow, so that there is no relation between the bulk of the species and the vegetation of the countries they inhabit.

The largest animals indigenous in the West India Islands are the Agouti, the Racoon, the Houtias, a native of the forests of Cuba; the carnivorous Didelphi and the Kinkajou are common to them and to the continent; the Kinkajou is a solitary instance of a carnivorous animal with a prehensile tail.

AUSTRALIAN QUADRUPEDS.

§ 6. Australia is not further separated from the rest of the world by geographical position than by its fauna. Its animals are creatures apart, of an entirely separate type; they are few as regards species, and still fewer as to individuals, if the vast extent of country be taken into consideration; and there has not been one large animal discovered in it. There are only about 60 species of terrestrial mammalia in Australia, and there is not a single example of the ruminating or pachydermatous animals, so useful to man, among them. There are no native horses, oxen, or sheep; yet all these thrive and multiply on the grassy steppes of the country, which seem to be so well suited to them. There are none of the monkey tribe; indeed, they could not exist in a country where there is scarcely any fruit.

Of the species of indigenous quadrupeds, nearly all are confined to this continent, and by far the greater number are marsupial animals, distinguished from all others by their young being as it were prematurely born and nourished in the pouch till they are able to fare for themselves.[1] Though all the members of this numerous family agree in this circumstance, they are dissimilar in appearance, internal structure, in their teeth and feet, consequently in their habits; two genera live on vegetable food, one group are gnawers, and another entirely deprived of teeth. The kangaroo and the kangaroo-rat walk on their hind legs, and advance by bounds, springing from their strong tail; the kangaroo-rat holds its food in its paws like the squirrel; the phalangers live on trees, and swing by their bushy tail—some burrow in the sand; the flying opossum, or Petaurus, peculiarly an Australian animal, lives at the foot of the Blue Mountains, on the leaves of the gum-tree; by expanding the skin of its sides as a parachute, it supports itself in the air in its leaps from bough to bough. Several of the genera are nocturnal, a characteristic of many Australian animals.

The pouched tribe vary in size from that of a large dog to a mouse; the kangaroos, which are the largest, are easily domesticated, and are used for food by the natives. Some go in large herds in the mountains, others live in the plains; however, they have become scarce near the British colonies, and, with all other native animals, are likely to be soon extirpated. In Tasmania they are less persecuted; several species exist there. The kangaroos are more widely dispersed than any of the marsupial animals of Australasia. They exist not only in Australia and Tasmania, but also in New Guinea. The banded kangaroo, the handsomest of his tribe, is found only in the islands in Shark Bay, on the W. coast of New South Wales. The wombat is peculiar to Australia, the islands in Bass Strait, and Tasmania; to which the two largest carnivorous marsupials peculiarly belong, called by the natives the Tiger Hyæna (*Thylacinus*) and the native Devil; both are nocturnal, predatory, and fierce. A wild dog living in the woods, whose habits are ferocious, is, with the tiger hyæna, the largest carnivorous animal in Australia.

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[1] There are 5 tribes, 15 genera, and more than 150 species of living marsupial animals, amounting to about one-twelfth of all the mammalia. The Opossum and Chironectes are American; the four other families are inhabitants of Australia and the Indian Archipelago.

The gnawing animals are aquatic and very peculiar; but the Monotremata of Australia are quite anomalous, and peculiar to the country; of these there are two genera, the Ornithorhynchus, or duck-billed mole, and the Echidna: they are the links that connects the Edentata with the pouched tribe, and mammalia with oviparous animals. The Ornithorhynchus is about 14 inches long, and covered with thick brown fur; its skull is similar to that of a quadruped, ending in a bill like that of a duck: it has short furry legs with half-webbed feet, and the hind feet are armed with claws and a sharp spur, the wounds from which are dangerous. It inhabits burrows on the banks of rivers, which have two entrances, one above, the other below the level of the water, which it seldom leaves, feeding on insects and seeds in the mud.

The Echidna is similar in its general structure to the ornithorhynchus, but entirely different in external appearance, being covered with spines like the porcupine; it is also a burrowing animal, sleeps during winter, and lives on ants in summer.

A singular analogy exists between Australia and South America in this respect, that the living animals of the two countries are of the same forms and types as the extinct races of their inhabitants, many of which are gigantic representatives of the now comparatively diminutive existing animals; while in the Old Continent the difference between the existing and extinct forms of beings is decided. Australia and South America seem still to retain some of those conditions that were peculiar to the most ancient geological eras. Thus each tribe of the innumerable families that inhabit the earth, the air, and the waters, has a limited sphere. How wonderful the quantity of life that now is, and the myriads of

CHAPTER XXXV.

DISTRIBUTION, CONDITION, AND PROSPECTS OF THE HUMAN RACE.

§ 1. Number and diversity of the human family; its division into six great varieties; the Caucasian group; the Mongol-Tartar group; Malayan group; Australasian group; Ethiopian group; American group. § 2. Language; its development with the progress of a nation; its varieties, affinities between languages indicating a common origin; adventitious character of language. § 3. European nations, their ethnological relations, —Teutons, Celts, and Sclavonians; dialects, changes in England; marked differences between races as to religion. § 4. Diversity of form and colour in the human race. § 5. Flexibility of the human constitution favourable to diffusion of man; relation of food to climate; constant renewal of the bodily tissues; effect of mental cultivation on the countenance; permanent characters of the human species. § 6. Centres of civilization; their dependence on animal and vegetable distribution; migrations; effect of mountain-chains on character of population. § 7. Influences of external circumstances on man; influence of man on nature. § 8. Domestication of animals; equilibrium of nature; domination of the whole earth by man; conclusion.

§ 1. More than 1,000,000,000[1] of human beings are scattered over the face of the earth, in all stages of civilization, from a high state of moral and intellectual culture, to savages but little above the animals that contend with them for the dominion of the deserts and forests through which they roam. This vast multitude is divided into nations and tribes, differing in external appearance, character, language, and religion. The manner in which they are distributed, the affinities of structure and language by which

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[1] The population of the world was thus estimated in 1855:—

			Square Miles.
Europe	265,398,000,	scattered over	3,768,000
Asia	652,500,000,	„	16,915,000
Africa	60,000,000,	„	11,376,000
America	57,359,680,	„	15,840,000
Australasia, including New Zealand	500,000,	„	3,038,000
Polynesia, unknown ..	..	„	1,170,000
	1,035,757,680	Sq. Miles	52,107,000

Keith Johnston's 'Phys. Atlas,' in fol. 1856.

they are connected, and the effect that climate, food, and customs may have had in modifying their external forms or their moral and mental powers, are subjects of much more difficulty than the geographical dispersion of the lower classes of animals, inasmuch as the immortal spirit is the chief agent in all that concerns the human race.

The human family consists of six great groups, marked by distinctive characters. Many nations and sub-varieties are included in each; distinguished from one another by difference of language, manners, and mental qualities, yet bearing such a resemblance in general physiognomy and appearance as to justify a classification apparently anomalous.

The Caucasian group of nations, which includes the handsomest and most intellectual portion of mankind, inhabit all Europe, except Lapland, Finland, and Hungary; they occupy Northern Africa, as far as the 20th parallel of N. latitude, Arabia, Asia Minor, Persia, the Himalaya chain to the Brahmapootra, all India between these mountains and the ocean, and, by recent migration, the various States of America. These nations are remarkable for a beautifully-shaped head, regular features, fine hair, and symmetrical form. The Greeks, Georgians, and Circassians are models of perfection in form, especially the last, which are assumed as the type of the Caucasian variety; of which it is evident that colour is not a characteristic, since they are of all shades, from the fair and florid to the clear dark brown and almost black. This family of nations has always been and still is the most civilized portion of the human race. The inhabitants of Hindostan, the Egyptians, Arabians, Greeks, and Romans, were in ancient times what European nations are now. The cause of this remarkable development of mental power is no doubt natural disposition, for the difference in the capabilities of nations seems to be as great as that of individuals. The origin of spontaneous civilization and superiority may generally be traced to the talent of some master-spirit gaining an ascendancy over his countrymen. Natural causes have also combined with mental; mildness of climate, fertility of soil; rivers and inland seas, by affording facility of intercourse, and favouring enterprise and commerce, the double-river systems in Asia having brought distant nations together, and softened those hostile antipathies which separate people, multiply languages, and reduce all to barbarism. The genius of this family of nations led them to profit by these natural advantages; whereas the American Indians are at this day wandering as barbarous hordes in one of the finest countries in the world. An original similarity or even identity of many spoken languages may be adverted to as having facilitated communication and mental improvement among the Caucasian variety in very ancient times.

The Mongol-Tartar races form the second group of nations. They occupy all Asia N. of the Persian table-land and of the Himalayas; nearly the whole of eastern Asia from the Brahmapootra to Behring Strait, together with the Arctic regions of America N. of Labrador. This family includes the Turkomans, Mongol and Tartar tribes, the Chinese, Indo-Chinese, the Esquimaux, and the Hungarians, now located in the very heart of Europe. These nations are distinguished by broad skulls and high cheek-bones, small black eyes obliquely set, long black hair, and a yellow or sallow olive complexion; some are good-looking, and many are well-made. A portion of this family is capable of high culture, especially the Chinese, the most civilised people of eastern Asia, although they never have attained the excellence of the Caucasian group, probably from their exclusive social system, which has separated them from the rest of mankind, and kept them stationary for ages; the peculiarity and difficulty of their language have also tended to insulate them. The Kalmuks, who lead a pastoral and wandering life on the steppes of central Asia, and the Esquimaux, have wider domains than any other of this group. The Kalmuks are rather a handsome people, and, like all who lead a savage life, have acute senses of seeing and hearing. The inhabitants of Finland and Lapland are nearly allied to the Esquimaux, who are spread over all the high latitudes of both continents—a diminutive race, equally ugly in face and form.

The third, or Malayan, group occupy the Malayan Peninsula, and the western portion of the Indian Archipelago, together with the Philippines and Formosa; and a sub-variety or section of the race is spread over eastern and central Polynesia, from the Sandwich group to New Zealand; this variety in physical structure and temperament seems a mixture of Papuan and Malay. The Japanese are also supposed to be an offshoot of the Malayan stock, who have migrated in prehistoric times from the Indian Archipelago to their present homes. The ruling race of Madagascar also belongs to the Malay stock. The Malayans are of brown complexion of skin, with long coarse black hair, flat faces, and obliquely set eyes. Endowed with great activity and ingenuity, they are mild and gentle, and far advanced in the arts of social life, in some places; in others ferocious and vindictive, daring and predatory; from their maritime position and skill, they are a migratory race. Several branches of this group of nations had a very early indigenous civilization, with an original literature written in peculiar characters of their own.

The fourth great section of the human race has been sometimes classed with the Malayan; this includes the Papuans, or inhabitants of New Guinea and neighbouring islands as far to the E. as the

Fiji or Viti group, and the Australians. They differ from the Malays by their darker skin, the crisp and bushy nature of their hair, and their more aggressive, demonstrative, and lively dispositions. Many of the tribes of central and southern Australia and the Tasmanians, who are now nearly extinct, are amongst the most degraded of mankind, and they offer many points of difference from the Papuans. Remnants of a dark-skinned and curly-headed race allied to the present are found in the Negritos of the Philippines, the Semangs of Malacca, and in the Andaman Islanders. It is also probable that several of the hill-tribes in the provinces E. of the Bay of Bengal, and in Southern India, are so many isolated remnants of this once widely spread section of the human species.

The fifth group of nations (the Ethiopian) are widely dispersed: they occupy all Africa S. of the Great Desert, and a large portion of the island of Madagascar. The distinguishing characters are, a black skin, with woolly or frizzled hair,[1] thick lips, projecting jaws, high cheek-bones, and large prominent eyes. A great variety, however, exists in this jetty race: some are handsome both in features and figure, especially in Ethiopia; and even in western Africa, where the Negroes live, there are tribes in which the distinctive characters are less exaggerated. This great family has not yet attained a high place in civilization, though by no means incapable of cultivation; part of Ethiopia appears to have made considerable progress in very ancient times. But the formidable deserts, so extensive in some parts of the continent, and the insalubrious climate in others, have cut off intercourse with civilized nations; and the infamous traffic in slaves, to the disgrace of Christianity, has rendered the inhabitants of tropical Africa more barbarous than they were before: while, on the contrary, the Foulahs and other tribes, who were converts to Mohammedanism 400 years ago, possess now large commercial towns, cultivated grounds, and schools.

The sixth, or American, group, who occupy the whole of the new continent from 62° N. lat. to the Strait of Magellan, are almost all of a reddish brown or copper colour, with long black hair, black eyes, aquiline nose, and often of handsome slender forms. In North America they live by hunting, are averse to agriculture, slow in acquiring knowledge, but extremely acute, brave, and fond of war, and, though revengeful, are capable of generosity and gratitude. Some tribes in Upper Canada are becoming civilized, and show a disposition to cultivate the earth when furnished with the necessary implements. In South America many are half-civilized, but a greater number are still in a state of complete barbarism. In a family so widely scattered great diversity of character prevails, yet throughout the whole there is a similarity of manners and habits which has resisted all the effects of time and climate.

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[1] Wool is peculiar to quadrupeds, the hair of the negro only resembles it. Both hair and wool consist of a transparent tube or sheath containing a white or coloured pith, but the sheath of hair is smooth, whilst that of wool is notched, which gives it the felting property.

Each of these six principal varieties of the human race consists of numerous nations and sections, offering a large amount of difference amongst themselves; and the difference not only affects the bodily structure and features, but also mental characteristics, language, and deeply rooted habits. It is sufficient to point out the obvious differences in these respects between the Celtic and Teutonic nations of Europe and between the mild, industrious, town-building red-men of northern Mexico and the wild Indians of the plains, the peculiarities of whose temperament are so ineradicable that they become extinct before civilization acquires any influence over them. No less striking is the difference between the colossal and muscular Patagonian and the dwarfed ill-shapen Fuegian, his near neighbour; and yet it is incontestable that all these belong to the same race of American red-men. In Africa equally remarkable is the difference between the degraded Bushman and Hottentot and the active, warlike Caffre, or the Mahommedan Negroes of the western Soudan. It is probable, however, that the intermixture of two primary varieties has had much to do with the production of some of these varieties. No doubt, people of the Semitic section of the Caucasian variety have from time immemorial intermingled, in northern and eastern Africa, and in the Valley of the Nile, with the northern nations of the Negro type. Some Egyptologists have suggested that the ancient Egyptians were a mixed race formed of the union of Semitic nations with Ethiopians. The world-old custom of domestic slavery has also had much to do with the mixture of races; the conquerors interbreeding with their captives. This must have prevailed extensively in south-western Asia, and it has also probably caused an interblending of the Mongol race with various nations of the Caucasian race in the plains of Turkestan, from the borders of the Caspian to the desert of Gobi. From these various considerations, it is not surprising that it is difficult to fix definite boundaries to the chief varieties of the human race, or to apply characters which shall be peculiar and common to all the subdivisions of one and the same variety.

§ 2. More than 2000 languages are spoken, but few are independent; some are proved to be varieties of one stock by being connected by words having the same meaning, and by grammatical structure; indeed, the permanency of language is so great that neither ages of conquest nor mixing with other nations have obliterated the native idiom of a people. The French, Spanish, and German retain traces of the common language spoken before the Roman conquest, and the Celtic tongue still exists in the British Islands.

By a comparison of their dialects, nations far apart, and differing in every other respect, are discovered to have sprung from a common though remote origin. Thus all the numerous languages spoken by the American Indians, or red men, are similar in grammatical structure: an intimate analogy exists in the languages of the Esquimaux nations who inhabit the arctic regions of both continents. Dialects of one tongue are spoken throughout North Africa, as far S. as the oasis of Siwah on the E., and the Canary Islands on the W. Another group of cognate idioms is common to the inhabitants of Equatorial Africa, while all the southern part of the continent is inhabited by people whose languages are connected. The monosyllabic speech of the Chinese and Indo-Chinese shows that they are the same people; and all the insular nations of the Pacific derived their dialects from some tribes on the continent of India and the Indian Archipelago. Cognate tongues are spoken by the Tartars, Manchus, Fins, Laplanders, many of the Siberian tribes, and by the Hungarians. The Syro-Arabian, or Semitic, languages, as the Chaldee, Arabic, and Hebrew, are evidently, from their grammatical construction, of the same origin.

The Persian, Greek, Latin, German, and Celtic tongues are connected by grammatical structure, and words expressive of the same objects and feelings, with the Sanscrit, or sacred language of India; consequently the nations inhabiting that vast extent of country from the mouth of the Ganges to the British Isles, the coast of Scandinavia and Iceland, are concluded to have had the same origin. The original stock of this most highly endowed family of nations is now, by common consent, termed Aryans, and their original seat is theoretically fixed as having been in the highlands of south-western Asia between Armenia and the Himalayas.

Notwithstanding the number of allied tongues, all attempts to trace them to a common origin have failed, which evidently proves that each race formed its own. The formation of language is adduced by Mr. Crawfurd as one of the many facts which attest the high antiquity of man. "Language is not innate, but adventitious; a mere acquirement, having its origin in the superiority of the human understanding, like any other acquisition derived from the same source. Infants are without language; they gradually acquire it as they improve in intelligence. Children learn any language with equal facility; they can forget their mother tongue and learn another. Among the unquestionable proofs that language is not innate is the prodigious number of languages which exist. some with a very narrow range of articulate sounds, others with a very wide one; some words confined to single syllables, and others having many; some being of very simple and others of a very complicated structure." Thus, language combines with geology in bearing testimony to the vast antiquity of the human race. That man has existed on earth immeasurably anterior to historical record there can be little doubt, since no absolute date can be assigned for the antiquity of the historical period prior, for instance, to the establishment in the valley of the Nile of a nation so highly advanced in civilization as the ancient Egyptians. It is obvious that innumerable centuries are required for the slow, spontaneous growth of civilizations like that of the Pharaohs. Moreover, the discovery of implements of bone and flint in caverns under conditions which show that a race existed in western Europe at that remote epoch when an arctic climate reigned in central France, and the reindeer abounded, places the great antiquity of our race beyond a doubt. Nor was this the earliest date of man's existence, for flint implements have been found embedded in drift beds which were deposited at an early epoch, as is indicated by the facts that the rivers of northern France have since worn down their valleys 200 feet, and the Solent has gradually worn through its passage between the Isle of Wight and Hampshire.

§ 3. The prevailing races of mankind now inhabiting Europe are the Teutonic, Celtic, and Sclavonian. In the greater part of the continent these races are mixed, but the blood is purely Teutonic throughout Iceland, Scandinavia, round the Gulf of Bothnia, in Denmark, Germany, and the E. of England from Portsmouth to the Tyne. Pure Celtic blood is confined to the Basque provinces in Spain, the S. and S.W. of France, a part of the Grisons in Switzerland, and the western parts of the British Islands. The Sclavonian blood is widely dispersed in middle Russia, from the Ural Mountains to the W. of the Valdai table-land, and from Novogorod to the countries bordering on the lower course of the Don. The three races have been much improved by mixture, in appearance, energy, and versatility of mind.

At present the Teutonic race, including the inhabitants of North America and the British colonies, considerably outnumbers the Celtic, though far inferior in ancient times. The Teutonic variety has subdued and even exterminated the other varieties in its progress towards the W.; it is undoubtedly the most vigorous, both in body and mind, of all mankind, and seems destined to conquer and civilize the whole world. It is a singular fact, whatever the cause may be, that the Celts are invariably Roman Catholic, while the Teutonic population is inclined to Protestantism, which consequently will go on increasing in its spread over the world with the intellectual race that professes it.

Various other races inhabit Europe, inferior in numbers to those above mentioned, though occasionally mixed with them, as the Turks, Fins, the Samojedes, who live on the shores of the White Sea and in the N.E. of Russia, and the Hungarians, the higher class of whom are a fine race of men, and on a par with the most civilized of the European nations.[1] There are many mixed Tartar tribes, chiefly in the S. and E. of the Russian territories; also Jews and Gipsies, who live among all nations, yet mix little with any.[2]

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[1] To explain which we must bear in mind that Europe had been inhabited before the arrival of the Asiatic tribes, consequently some of the inhabitants of the more remote regions are probably the aborigines of the country.

[2] EUROPEAN POPULATION.

Pure Blood.

Teutonic	52,000,000
Sclavonian	50,000,000
Celtic	12,000,000
Magyar	9,000,000
Fins and Samojedes	3,000,000
Tartar in South Russia	2,000,000
Jews	2,000,000
Total European population of pure blood	130,000,000

Mixed Blood in Europe.

Teutonic-Celtic in Great Britain and Ireland	22,000,000
Teutonic-Sclavonian	6,000,000
Teutonic, pure and mixed with Walloons, in Belgium	1,200,000
Teutonic Northmen in Normandy and other parts of France	1,500,000
Celtic in its different varieties in France, Spain, Portugal, Italy, and Switzerland	56,000,000
Sclavonian in Germany, Bohemia, Wallachia	6,000,000
Lettons	2,000,000
Turks	4,000,000
Turco-Tartar-Sclavonic in centre, south-east, and east of Russia	2,600,000
Kalmuk, between the Volga and Ural ..	300,000
The number of people of mixed blood in Europe	101,600,000

The total population of Europe, pure and mixed, amounts to about 260 millions, including about 2,230,000 Jews. The Teutonic population in the

The inhabitants of Great Britain are of Celtic and Teutonic origin. The Celtic blood is purest in Cornwall and the Scilly Islands, in Wales, and the Isle of Man: in the highlands of Scotland and the Hebrides it is more mixed than is generally supposed, as plainly appears from the frequency of red hair and blue eyes. In some parts of Ireland there is pure Celtic blood, but throughout the greater part of that country it is mixed, although the Celtic character predominates; but in Ulster, where the earliest colony settled, the blood is Teutonic. In Ireland the difference in the organization of the two races is strongly marked: placed under the same circumstances the Teutonic part of the population has prospered, which, unfortunately, has not been the case, to the same extent, with the Celtic.

The dialects spoken in the Celtic districts are closely allied to the Semitic languages of Asia, and to one another. The Cornish is worn out, the Manx is nearly so, and the Gaelic is declining fast in the Hebrides and highlands of Scotland.

The races of mankind are equally distinguished from one another by their religious opinions. Europe is Christian; Catholicism is the faith in the S.W.; and it has been observed that, wherever the spoken language is derived from that of ancient Rome, the creed of modern Rome prevails. In the E. of Europe the Sclavonians are of the Greek Church, and in N. and Central Europe the people are Protestant. From the Atlantic along the northern coast of Africa, and from Turkey in Europe through Persia to India, the inhabitants are for the most part Mohammedans; Brahminism, Buddhism, and other forms of idolatry prevail through the rest of the Asiatic continent.

In the central States and the British provinces of North America, the great proportion of the population is Protestant; Mexico and a large portion of South America are nominally Catholic; and the rest of the southern continent, with a few exceptions, is in the lowest state of barbarism.

§ 4. Ethnologists are not at present in accord regarding the origin of the varieties of the human race. A desultory discussion has been carried on for many years on the question whether man had one only, or many, origins; or, as it is generally put, whether there are one or many species of the genus *homo*. In the absence

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United States of North America and in the British colonies amounts to 20 millions; so that the total number of people of Teutonic blood is rather more than 100 millions.—Notes accompanying the Ethnographic Map of Europe, by Dr. Gustaf Kombst; Keith Johnston, 'Phys. Atlas,' 1856. By a more recent census the population of Europe has been estimated at 265,398,000.

of any definition of the term species, and of explanation of what is understood by "origin," such discussions can bear but little fruit, and in fact they are injurious to the best interests of science, as diverting the attention from the investigation of the causes which have produced the differences between nations and races. No problems in biological science seem farther from solution than the causes of the diversity in form, colour, mental disposition, and so forth, of mankind. Many instances have occurred in modern times of albinos and red-haired children having been born of black parents, and these have transmitted their peculiarities to their descendants for several generations; but it is extremely doubtful whether pure-blooded white parents have produced a black offspring. The varieties are much more likely to have arisen from the effects of climate, food, customs, and civilization upon migratory groups of mankind; and of such, a few instances have occurred in historical times, limited, however, to small numbers and particular spots; but the great mass of nations had received their distinctive characters at a very early period, for there is no instance on record of a new variety having been established as a nation.

Other causes than the sun must have been combined to occasion all the varieties we now see, otherwise every nation between the tropics would be of the same hue, whereas the sooty negro inhabits equatorial Africa, the red man equinoctial America, and both are mixed with fairer tribes. In Asia, the Rohillas, a fair race of Affghan extraction, inhabit the plains N. of the Ganges; the Bengalee and the mountaineers of Nepaul are dark, and the Mahrattas are yellow. The complexion of man varies also with height above the sea and the latitude of the region he lives in; some of the inhabitants of the Himalaya and Hindoo Koosh are fair, and even a red-haired race is found on the latter. There are fair-haired people with blue eyes in the Ruddhua mountains in Africa. The Kabyles, that inhabit the country behind Tunis and Algiers, are similar in complexion to the nations in northern latitudes. This correspondence, however, holds good only with regard to the northern hemisphere, for it is a well-known fact that the varieties of the numerous species in the southern continents are much more similar in physical characters to the native races of the torrid zone than any of the aboriginal people of the northern regions. Even supposing that diversity of colour is owing to the sun's rays only, it is scarcely possible to attribute to them the thick lips, the woolly hair, and the difference of form, extending even to the bones and the skull.

§ 5. The flexibility of man's constitution enables him to live in every climate, from the equator to the ever-frozen coasts of Novaia Zemlia and Spitzbergen, and that chiefly by his capability of bearing the most extreme changes of temperature and diet, which are probably the principal causes of the variety in his form. It has already been mentioned that oxygen is inhaled with the atmospheric air, and also taken in by the pores in the skin; part of it combines chemically with the carbon of the food, and is expired in the form of carbonic acid gas and water; and that chemical action is the cause of vital force and heat in man and animals. The quantity of food must be in proportion to the quantity of oxygen inhaled, otherwise disease and loss of strength would be the consequence. Since cold air is incessantly carrying off warmth from the skin, more exercise is requisite in winter than in summer, in cold climates than in warm; consequently more carbon is necessary in the former than in the latter, in order to maintain the chemical action that generates heat and to ward off the destructive effects of the oxygen, which is incessantly at work in consuming the body. Animal food, wine, and spirits contain more carbon than fruit and vegetables, therefore they are much more necessary in a cold than in a hot climate. The Esquimaux, who lives by the chace and eats 10 or 12 pounds of meat and fat in 24 hours, finds it not more than enough to keep up his strength and animal heat, while the indolent inhabitant of Bengal is sufficiently supplied with both by his rice diet. Clothing and warmth render the necessity for exercise and food much less by diminishing the waste of animal heat. Hunger and cold united soon consume the body, because it loses its power of resisting the action of the oxygen, which consumes part of our substance when food is wanting. Hence nations inhabiting warm climates have no great merit in being abstemious, nor can those be considered guilty of committing an excess who live more freely in colder countries. The arrangement of Divine Wisdom is to be admired in this as in all other things, for, if man had only been capable of living on vegetable food, he never could have had a permanent residence beyond the latitude where corn ripens. The Esquimaux and all the inhabitants of very high latitudes of both continents live entirely on fish and animal food. What effects the difference of food may have upon the intellect it is difficult to determine.

A nation or tribe driven by war or any other cause from a warm to a cold country, or the contrary, would be forced to change their food both in quality and quantity, which in the lapse of ages might produce an alteration in the external form and internal structure. The probability is still greater if the entire change that a few years produce in the matter of which the human frame is composed be considered. At every instant during life, with every motion, voluntary and involuntary, with every thought and every exercise of the brain, a portion of our substance becomes dead, separates from the living part, combines with some of the inhaled oxygen, and is removed. By this process it is supposed that the whole body is renewed every seven years; individuality, therefore, depends on the spirit, which retains its identity during all the changes of its earthly house, and sometimes even acts independently of it. When sleep is restoring exhausted nature, the spirit is often awake and active, crowding the events of years into a few seconds, and by its unconsciousness of time anticipates eternity. Every change of food, climate, and mental excitement must have its influence on the reproduction of the mortal frame; and thus a thousand causes may co-operate to alter whole races of mankind placed under new circumstances, time being granted.

The difference between the effects of manual labour and the efforts of the brain appears in the intellectual countenance of the educated man, compared with that of the peasant, though even he is occasionally stamped with nature's own nobility. The most savage people are also the ugliest. Their countenance is deformed by violent unsubdued passions, anxiety, and suffering. Deep sensibility gives a beautiful and varied expression, but every strong emotion is unfavourable to perfect regularity of feature; and of that the Greeks were well aware when they gave that calmness of expression and repose to their unrivalled sculpture. The refining effects of high culture, by subduing the evil passions and encouraging the good, are more than anything calculated to improve even the external appearance. The countenance, though perhaps of less regular form, becomes expressive of the amiable and benevolent feelings of the heart, the most captivating and lasting of all beauty.[1]

Thus an infinite assemblage of causes may be assigned as having produced the endless varieties in the human race: the fact remains an inscrutable mystery, the more so as the permanency of type is one of the most striking circumstances, and proves the length of time necessary to produce a change in natural structure and colour. The national appearance of the Ethiopians, Persians, and Jews, has not varied for more than 3000 years, as appears from the ancient Egyptian paintings in the tomb of Rhamses the Great, discovered at Thebes by Belzoni, in which the countenances of the modern Ethiopian and Persian can be readily recognised, and the Jewish features and colour are identical with those of the Israelites daily met with in the streets of London. The unaltered state of the two former may perhaps be attributed to the unchanged circumstances and climate in which they have lived; not so with regard to the Jews, who, though they have become fair in some parts of Europe, retain a permanency of type not to be mistaken.

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[1] The countenances of the Fuegians brought to England in 1830 by Captain FitzRoy improved greatly in expression by their intercourse with civilized men, but they had not returned to their savage brethren more than a year before their whole appearance was completely changed; the look of intelligence they had acquired was gone; and when compared with likenesses that had been taken of them when in England, they were not to be recognised as the same persons.

§ 6. It is supposed that the seats of the earliest discernible civilizations were the mountainous parts of the continents, whence the divers tribes descended and diffused themselves gradually, as geological causes permitted the low lands to be habitable, so that the diffusion became an index of geological changes.

Animals and vegetables, being the sources of man's sustenance, have had the chief influence on his destiny and location, and have induced him to settle in those parts of the world where he could procure them in greatest abundance. Wherever the chace or the spontaneous productions of the earth supply him with food, he is completely savage, and only a degree further advanced where he plants the palm and the banana; where grain is the principal food, industry and intelligence are most perfectly developed, as in the temperate zone. On that account the centres of civilization have generally been determined, not by a hot, but by a genial climate, fertile soil, by the vicinity of the sea-coast or great rivers, affording the means of fishing and transport, which last has been one of the chief causes of the superiority of Europe and Southern Asia. The mineral treasures of the earth have been the means of assembling large masses of men in Siberia, on the table-land of the Andes, in California, Australia, and British Columbia, and have given rise to many large cities both in the Old and the New World. Nations inhabiting high ungenial latitudes have often been driven there by war, or obliged to wander from countries where the population exceeded the means of existence—a cause of migration to which both language and tradition bear testimony. The belief in a future state, so universal, shown by respect for the dead, has no doubt been transmitted from nation to nation. The American Indians, driven from their hunting-grounds, still make pilgrimages to the tombs of their fathers; and these tribes alone, of all uncivilized mankind, worship the Great Spirit as the invisible God and Father of all.

It is probable that America was peopled from Asia before the separation of the continents by Behring Strait, or at any rate at an epoch when a milder climate existed in that latitude than now prevails there. Probably a race of mankind had migrated from France to Britain before the English Channel was formed: and there is reason to suppose that the location of various races of mankind, now insulated, may have taken place before the separation of the lands by mediterranean seas; whilst others, previously insulated, may be now united by the drying up of inland seas, as those which covered the Saharan Desert and the great hollow round the Caspian Sea, of which it and the Black Sea are the remnants. It was probably at that period that North Africa was peopled by tribes which descended from the high lands of Senegambia and Abyssinia.

From the earliest period of the peopling of the earth by man, a never ceasing process of migration has in all probability been going on. In Europe we may dimly see by the light of history and the signs of earlier races revealed by buried bones, weapons, and implements, that wave after wave of population has spread over the land; the earlier races being either exterminated, driven into remote corners of the continent, or amalgamated with the new comers. This, it is fair to assume, has been the case over the whole earth. The successive re-peoplings of countries and continents cannot have been effected without prolonged life and death struggles, resulting in the victory of the more vigorous and intelligent race, and thus a population of higher mark than the preceding one has, time after time, overspread the land. How the new invaders have acquired their superior qualities, corporeal and mental, is a subject for the investigation of ethnologists and philosophers. It is probable they have slowly grown in limited districts, under the influence of favourable local conditions, and possibly of some few able men happily born among them. An active spirit or a population outgrowing the means of subsistence are the incentives to migration and conquest; the improved race is thus widely spread, and fresh and improved developments again take place in limited portions of the newly peopled area.

M. Boué has observed that mountain-chains running nearly E. and W. establish much more striking differences among nations than those which extend from N. to S.—a circumstance confirmed by observation through the history of mankind. The Scandinavian Alps have not prevented the countries on both sides from being occupied by people of a common descent; while the feeble barrier of the Cheviot Hills, between England and Scotland, and the moderate elevation of the Highland mountains, have prevented the amalgamation of the Anglo-Saxons and the Celts, even in a period of high civilization. The Franks and Belgians are distinct, though separated by hills of still less elevation. For the same reason the Spaniards and Italians differ far more from their neighbours on the other side of the eastern and western chains than the Spaniards do from the Portuguese, or the Piedmontese from the Provençals. A similar distinction prevails throughout Asia; and in America, where all the principal chains run N. and S., there is but one copper-coloured race throughout the continent, which stretches over more climates than Europe and Africa, or even than Asia and Australia united. It is in general along chains running N. and S. that the fusion of languages takes place, and not along those of an easterly and westerly direction. From Poland, for instance, there are intermediate insensible gradations through Germany into France; while in crossing from a German district of the Alps to the valleys of Italy, different tribes and different languages are separated by a single mountain. Even wars and conquest have ever been more easy in one direction than in the other. The difference in the fauna and flora on the two sides of the great tablelands and mountains of Asia is a striking illustration of the influence which high lands running E. and W. have on natural productions, and thus, both directly and indirectly, they affect the distribution of mankind.

The circumstances which thus determine the location of nations, and the fusion or separation of their languages, must, conjointly with moral causes, operate powerfully on their character. The minds of mankind, as well as their fate, are influenced by the soil on which they are born and bred. The natives of elevated countries are attached to their mountains; the Dutch are as much attached to their meadows and canals; and the savage, acquainted only with the discomforts of life, is unhappy when brought among civilized man. Early associations never entirely leave us, however much our position in life may alter; and strong attachments are formed to places which generate in us habits differing from those of other countries.

§ 7. The Baltic and Mediterranean Seas have had no inconsiderable share in civilising Europe; one combined with a cold and gloomy climate, the other with a warm and glowing sky, have developed dissimilar characters in the temperament and habits of the surrounding nations, originally dissimilar in race. The charms of climate and the ease with which the necessaries of life are procured were favourable to the development of imagination in the more southern nations, and to an indolent enjoyment of their advantages. In the N., on the contrary, the task imposed upon man was harder, and perhaps more favourable to strength of character. The Dutch owe their industry and perseverance to their unceasing struggle against the encroachments of the ocean; the British are indebted to their insular position for their maritime character, and to the small extent of their country and the richness of their mines for their manufacturing and colonizing habits; the military propensities of the French are owing to the necessity of maintaining their independence among the surrounding nations, as well as to ambition and the love of fame. Thus external circumstances materially modify the character of nations, but the original propensities of race are never eradicated.

The power of external circumstances over man is not greater than his influence on the material world. He cannot create power, it is true, but he dexterously avails himself of the powers of nature to subdue nature. Air, fire, water, steam, gravitation, electricity, his own muscular strength, and that of animals rendered obedient to his will, are the instruments by which he has converted the desert into a garden, drained marshes, cut canals, made roads, turned the courses of rivers, opened communications, cleared away forests in one country, planted them in another, and compelled the dread lightning to bear his messages through the air, the earth, and even the deep waters. By these operations he has altered the climate, changed the course of local winds, increased or diminished the quantity of rain, and softened the rigour of the seasons. In the time of Strabo the cold in France was so intense that it was thought impossible to ripen grapes N. of the mountains of the Cevennes: the Rhine and the Danube were every winter covered with ice thick enough to bear any weight. Man's influence on vegetation has been immense, and it is chiefly through his tendency to cut down forest-trees, the natural clothing of the land, that he has produced the greatest amount of change on the surface of the earth. Forests in warm climates are essential to the fertility of a country. They act as a regulator of the annual rainfall, by preventing too rapid evaporation from the soil and creating a stratum of cooler atmosphere above it; the effect of these functions being that the amount of rain falling is moderated and spread over a greater number of days. In warm countries like Australia, Arabia, some parts of Southern Europe and India, districts which have no clothing of trees, or have been deprived of it by the hand of man, the rainfall descends in sudden deluges, and the dry seasons are excessively prolonged. Thus the violent rain-wash prevents the accumulation of humus or fertile soil, and the surface of the earth is scorched to sterility by months of fierce sun. In the S. of France the deterioration of climate by felling the timber on the hill slopes has been distinctly observed during the past century, and legislative enactments have been found necessary to protect what remains and restore what has been lost.[1] It is probable that whole countries in Asia Minor, Syria, Mesopotamia, and Northern Africa, would have had another destiny since classic times, had a more intelligent practice been followed regarding the forests which they once formerly possessed. Man has adapted many natural products to his wants, and made them the instruments of his advancement. The olive, the vine, and the fig-tree have been culitvated time immemorial; wheat, rice, and barley have been so long in an artificial state that their origin is unknown; even maize, which is an American plant, was in use among the tribes of that continent before the Spanish conquest; and tobacco was already used by them to allay the pangs of hunger, to which those who depend upon the chace for food must be exposed. Most of the ordinary culinary vegetables have been known for ages, and it is remarkable that in these days, when our gardens are adorned with innumerable native plants in a cultivated state, few new grains, vegetables, or fruits, have been reclaimed; the old have been produced in infinite variety, and many new brought from foreign countries.

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[1] Consult the excellent work by Mr. G. P. Marsh, 'Man and Nature; or Physical Geography as modified by Human Action.'

§ 8. Animals yield more readily to man's influence than vegetables, and certain classes have greater flexibility of disposition and structure than others. Those only are capable of being perfectly reclaimed that have a natural tendency for it, without which man's endeavours would be unavailing. This predisposition is greatest in animals which are gregarious and follow a leader, as elephants, dogs, horses, and cattle do in their wild state; yet even among these some species are refractory, as the buffalo, which can only be regarded as half reclaimed. The canine tribe, on the contrary, are capable of the greatest attachment: not the dog only, man's faithful companion, but even the wolf and the hyæna, generally so ferocious. After an absence of many months a hyæna, which had been the fellow-passenger of a friend of the author in a voyage from India, recognised his voice before he came in sight, and on seeing him showed the greatest joy, lay down like a dog, and licked his hands. He had been kind to it on the voyage, and no animal forgets kindness, which is the surest way of reclaiming them. There cannot be a greater mistake than the harsh and cruel means by which dogs and horses are too commonly trained; but it is long before man learns that his power is mental, and that it is intellect alone that has given him dominion over the earth and its inhabitants, of which so many far surpass him in physical strength. The useful animals were reclaimed by the early inhabitants of Asia, and it is very remarkable, notwithstanding the enterprise and activity of the present times, that among the multitudes of animals that inhabit America, Central and Southern Africa, Australia, and the Indian Archipelago, four only have been domesticated, yet many may be capable of becoming useful to man. Of 35 species of which we possess one or more domestic races, 31 are natives of Asia, Europe, and North Africa; these countries are far from being exhausted, and an entire hemisphere is yet but very partially explored. An attempt has been made to domesticate the llama, the dziggetai, zebra, and some species of Indian deer, but the success is very problematical. Little has been left for modern nations but the improvement of the species, and in that they have been very successful. The variety of horses, dogs, cattle, and sheep, is beyond number. The form, colour, and even the disposition, may be materially altered, and the habits engrafted are transmitted to the offspring, as instinctive properties independent of education. Domestic fowls go in flocks on their native meads when wild. There are, however, instances of solitary birds being tamed to an extraordinary degree, as the raven, one of the most sagacious.

Man's necessities and enjoyments have been the cause of great changes in the animal creation, and his destructive propensity of still greater. A farmer sees the rooks pecking a little of his grain, or digging at the roots of the springing corn, and poisons all in his neighbourhood. A few years after he is surprised to find his crop destroyed by grubs. The works of the Creation are nicely balanced, and man cannot infringe the laws of equilibrium with impunity. Insects would become torments were they not kept in check by birds. Animals soon acquire a dread of man, which becomes instinctive and hereditary: in newly discovered uninhabited countries birds and beasts are so tame as to allow themselves to be caught; whales scarcely got out of the way of the ships that first navigated the Arctic Ocean, but now they universally have a dread of the common enemy: whales and seals have been extirpated in various places: sea-fowl and birds of passage are not likely to be extinguished, but many land animals and birds are disappearing before the advance of civilization. Drainage, cultivation, cutting down of forests, and even the introduction of new plants and animals, destroy some of the old and alter the relations between those that remain. The inaccessible cliffs of the Himalaya and Andes will afford a refuge to the eagle and condor, but the time will come when the mighty forests of Bhotan, of the Amazon and Orinoco, will disappear with the myriads of their joyous inhabitants.

This time is at present, however, extremely remote. It is true that the process of occupying and replenishing the earth, by the most active and restless section of our species, is advancing with accelerating rapidity. All the remaining central part of one of the largest continents of the earth is now fast filling up with civilized inhabitants. It is mapped into states, territories, and counties, and a line of iron road, over which pants the irresistible locomotive, spans the wide region from ocean to ocean. A migration of vastness unheard of before in the history of the globe, amounting to 400,000 souls per annum, streams from the shores of Europe to this rapidly advancing new continent. In the other hemisphere, too, Australia and New Zealand are fast becoming peopled by the same process.

But it will be long indeed before the whole of the fertile land of the earth is occupied by a progressive, civilized people. The great interior plains of South America alone would sustain a larger population than China, and at present their inhabitants are only in the proportion of one to four square miles of territory. The enervating climate of the country will render the settlement of this great region by the Caucasian race an extremely slow process. The same may be said of the intractable continent of Africa, which possesses a wide region of comparatively healthy upland in its broad interior, but which offers, in the deadly climate of its coast-lands, a formidable obstacle to the occupation of the better tracts by a higher race than has now the possession of the land. The natural forest clothing of a great portion of these continents, with its myriads of curious and beautiful forms of animal and vegetable life, is destined probably to disappear, and man alone, with his cultivated plants and domesticated animals, will occupy the place of the natural tenants: but there will remain many a rugged valley in the lofty mountain ranges, and many a league of inaccessible swamp to serve as a refuge for a large portion of the native faunas and floras. We may hope, moreover, that with the increase of wealth, leisure, knowledge, and refinement, which happily seems a secure prospect for the long vistas of the future, man will endeavour to preserve the equilibrium which exists in the meteorological forces and vital conditions of countries, when in their natural state, by fostering a due proportion of woodland, and thus save from extinction the myriad beauteous forms of life which have shared with him the inheritance of this wonderful earth.

APPENDIX.

TABLE OF HEIGHTS ABOVE THE SEA

OF SOME

REMARKABLE POINTS OF THE GLOBE.

EUROPE.

Names of Places, Mountains, &c.	Heights in English Feet.	Countries in which situated.	Authorities.
MONT BLANC .. .. Alps, P.[1]	15,784	Italy	P. S.[2]
Monte Rosa .. .. ,, P.	15,217	,,	,,
Monte Cervin, or Matterhorn .. .. ,, P.	14,705	,,	,,
Grand Combin .. .. ,, P.	14,164	,,	F. S.
Finsteraarhorn .. .. ,, B.	14,026	Switzerland	Eschman.
Jungfrau.. .. .. .. ,, B.	13,672	,,	,,
Le Géant du M. Blanc .. ,, P.	13,786	Italy	P. S.
Grossglockner	12,957	Austria	Schlagintweit.
Mont Viso .. .. .. ,, C.	12,584	,,	Corabœuf.
Grand Paradis .. .. ,,	13,300	Iseran ?	A. S.
Mont Pelvoux.. .. .. ,, M.	13,422	France	,,
Bernina .. .. ,, R.	13,294	,,	F. S.
Orteler-Spitz .. .. .. ,, R.	12,789	Austria	Von Welden.
Le Grand Rioburent .. ,, M.	11,063	,,	P. S.
Dreiherren-Spitz .. .. ,, Car.	10,122	,,	A. S.
Mount Terglou .. .. ,, J.	9,343	,,	Baumgarten.
Passes of the Alps:[3]—			
Col of the Weissthor .. Alps, P.	11,851	Switzerland	P. S.
Col du Géant .. .. .. ,, P.	11,238	Italy	Saussure.
Col de St. Théodule .. ,, P.	10,899	,,	F. S.
Pass of the Gt. St. Bernard ,, P.	8,173	,,	,,
,, Furka .. .. ,, L.	8,174	Switzerland	S. S.

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[1] The letters affixed indicate the part of the Alps to which each locality belongs—M., Maritime; C., Cottian; G., Graian; P., Pennine; L., Lepontine; B., Bernese, or Helvetian; R., Rhetian; J., Julian; Car., Carniac.

[2] The authorities on which these heights are given are—the Piedmontese Survey. (P. S.), as published in 1845, in the work entitled 'Le Alpi che cingono l' Italia,' 1 vol. 8vo.; the Austrian Survey (A. S.), as given in the Maps of the Regno Lombardo-Veneto, published by the Austrian Government; and the Swiss Federal Trigonometrical Survey (F. S.).

[3] The first eight passes are only fit for foot passengers, and in certain seasons for mules; the remaining eleven offer carriage-roads, and are generally open at all seasons of the year, with the exception of the Stelvio.

Names of Places, Mountains, &c.		Heights in English Feet.	Countries in which situated.	Aut
Pass of the Monte Moro	Alps, P.	9,390	Switzerland	F. S.
,, Traversette	,, C.	9,827	Italy	,,
Col della Rella	,, C.	9,196	,,	,,
Col des Fenêtres	,, P.	9,581	,,	,,
Pass of the Stelvio	,, R.	9,177	Austria	A. S.
,, Bernardino	,, R.	7,015	Italy	,,
,, Splügen	,, R.	6,946	Austria	,,
,, St. Gothard	,, R.	6,808	Switzerland	S. S.
,, Mont Cenis	,, G.	6,772	Italy	P. S.
,, Simplon	,, L.	6,578	Switzerland	,,
Col di Tenda	,, M.	6,159	Italy	,,
Pass of the Mont Genèvre	,, C.	6,119	,,	,,
,, Brenner	,, R.	4,659	Austria	A. S.
,, Pontebba	,, J.	3,625	,,	,,
Pic de Nethou		11,168	Pyrenees	Coello
Mont Perdu Peak		10,994	,,	A. B.
Maboré, Cylinder of		10,899	,,	,,
Maladetta, ,,		10,886	,,	,,
Vignemale, ,,		10,820	,,	,,
Pic du Midi		9,540	,,	,,
Canigou		9,137	,,	,,
Port d'Oo	*Passes of the Pyrenees.*	9,846	,,	,,
,, d'Estaube		8,402	,,	,,
,, de Venasque		7,930	,,	,,
,, de Gavarnie		7,654	,,	,,
,, de Tourmalet		7,143	,,	,,
Mont Ventoux		6,263	France	,,
Pic de Sancy		6,188	,,	,,
Plomb du Cantal		6,093	,,	,,
Mont Mezen		5,795	,,	,,
Puy-de-Dôme		4,806	,,	,,
Ballon des Vosges		4,688	,,	,,
Mulahaçen		11,423	Spain	Coello,
Sierra de Gredos		10,552	,,	Bory.
Estrella		7,526	,,	Franzi
Siete Picos		7,244	,,	Bauza,
Peña Laza		8,222	,,	,,
El Gador		6,575	,,	Rojas (men
Monte Corno, or il Gran Sasso d' Italia		10,206	Italy, Apen.	Schouv
Monte Amaro di Majella		9,113	,,	,,
Monte Velino		7,851	,,	De Pr
Termenillo Grande		7,212	,,	Schow,
Monte Cimone		6,975	,,	,,
Mont Amiata		5,794		

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[1] Heights taken from the list published in the French 'Annuaire du Bureau d tudes,' converted from mètres into English feet.

Names of Places, Mountains, &c.	Heights in English Feet.	Countries in which situated.	Authorities.
Vesuvius, Punta del Palo, Aug. 1847	3,947	..	Chev. Amanti.
Monte Somma	3,869	..	,,
Monte Cavo (Mons Lazialis)	3,130	Campagna of Rome	French Survey.
St. Oreste, or Soracte	2,140	,,	,,
Passes of the Apennines:—			
Pass of the Giovi	1,550	Apennines	French Survey.
,, of La Bochetta	2,550	,,	Schow.
,, of the Pietramala	3,294	..	,,
Islands of the Mediterranean:—			
Monte Rotondo	8,767	Corsica	A. B. L.
,, d'Oro	8,701	,,	,,
,, Gennargentu	6,293	Sardinia	La Marmora.
Mount Etna	10,874	Sicily	W. H. Smyth.
Pizzo di Cane	6,509	,,	A. B. L.
Mount Eryx	3,894	,,	,,
Stromboli	2,687	Lipari Isles	De Borch.
Greece and the Morea:—			
Mount Guiona	8,239	Greece	Peytier.[1]
Parnassus	8,068	..	,,
Taygetus, Mont St. Elias	7,904	..	,,
Mount Olonas	7,296	..	,,
,, Kelmos	7,726	..	,,
,, Athos	6,778	..	De Borch.
,, Helicon	5,738	..	Peyter.
Delphi	5,725	..	,,
Mount Hymettus	3,378	..	,,
Central Europe:—			
Ruska Joyana	9,912	E. Carpaths.	
Butschetje, Transylvania	9,528	,,	
Surrul	9,593		
Mount Tatra, highest point	8,524	W. Carpaths.	Wahlenberg.
,, Csabi Peak	8,314	,,	,,
,, Lomnitz Peak	8,799	,,	
Riesenkoppe, in the Riesengebirge	5,394	Germany	Horen.
Feldberg, in the Schwarzwald	4,675	,,	French Engineers.
Belchenberg ,, ,,	4,642	,,	,,
Kandelberg ,, ,,	4,160	,,	Bohnenberger.
Schneeberg, Riesengebirge	4,784	,,	

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[1] Heights determined during the French expedition to the Morea by Colonels Peytier nd Boblaye, and published in the 'Connaissance des Temps' for 1839.

Names of Places, Mountains, &c.	Heights in English Feet.	Countries in which situated.	Auth
Kammkoppel, Riesengebirge	4,265	Germany	Charpe
Sonnenwerbel, in the Erzgebirge	4,124	,,	
Rachelberg, in the Böhmerwald	4,561	,,	Sternbe
Steinberg, Moravia	3,511	,,	David.
Brocken, Harz	3,658	,,	Zach.
Schneeberg, in the Fichtelgebirge	3,461	,,	Goldfus
Blessberg, in the Thüringerwald	2,748	,,	Zach.
Glockner ,, ,,	2,231	,,	,,
Gross-Feldberg, in the Taunus Chain	2,775	,,	Schmid
Löwenberg, in the Siebengebirge	2,024	,,	Nose.
Norway and Sweden:—			
Ymesfjeld	8,400	Scandinavian Mountains	Forbes.
Skagtölstind Lat. 61° 24′	8,101	,,	Keilhau
Koldetind	7,224	,,	,,
Sognefjeld	7,182	,,	Hagelst
Mugnafjeld Lat. 61° 20′	7,215	,,	Forsell.
Sneehætten ,, 62 20	8,120	,,	Eismar
Pighætten ,, 62 2	6,788	,,	Hagelst
Goustafjeld	6,200	,,	Forbes.
Sulitjelma Lat. 67° 5′	6,178	,,	Wahlen
Langfjeld ,, 61 53	6,598	,,	Hagelst
Dovrefjeld	5,360	,,	Forbes.
Melderskin Lat. 60° 0′	4,859	,,	Von Bu
Folgefond Glacier	5,460	,,	Forbes.
Lyngen Mountains Lat. 69° 30′	4,300	,,	,,
Great Britain:—			
Ben Nevis	4,406	Scotland	Ord. Su
Cairntoul, Aberdeenshire	4,285	,,	Keith.
Ben Avon ,,	3,826	,,	Ord. Su
Ben Lawers, Grampians	3,984	,,	,,
Schihallien ,,	3,564	,,	,,
Snowdon	3,590	Wales	,,
Cader Idris	2,959	,,	,,
Carn Llewellyn	3,471	,,	,,
Cross Fell, Cumberland	2,927	England	,,
Helvellyn ,,	3,313	,,	,,
Skiddaw ,,	3,038	,,	Dr. You
Schunner Fell, Yorkshire	2,388	,,	Smith.
Coniston Fell, Lancashire	2,575	,,	,,
Cheviot Hill	2,688	,,	Ord. Su
Pentland Hills (E. Cairn)	1,839	Scotland	,,
Carran Tual, Kerry	3,412	Ireland	Nimmo.
Sleive Donnard	2,778	,,	Ord. Su
Nephin, Mayo	2,638	,,	,,
Mourne Mountains, Down	2,493	,,	,,
Ben More, Isle of Mull	3,185	Hebrides	,,

Names of Places, Mountains, &c.	Heights in English Feet.	Countries in which situated.	Authorities.
Hecla, Isle of S. Uist	3,002	Hebrides	Boué.
Cuchullin, Isle of Skye	2,995	,,	M'Culloch.
Mount Rona	3,593	Shetland	Laing.
Arrenig	2,816	Wales	Ord. Survey.
Bencleuch	2,352	Scotland	,,
Ben Celibrig	3,157	,,	,,
Ben Lomond	3,192	,,	,,
Ben Macdui	4,296	,,	,,
Ben Wyvis	2,422	,,	,,
Brandon Hill (Kerry)	3,119	Ireland	,,
Cradle	2,660	Wales	,,
Dunrich, or Gumscleuch	2,432	Scotland	,,
Galteemore	3,007	Ireland	,,
Glashmeal	3,501	Scotland	,,
Goatfell, Arran	2,874	,,	,,
Great Whernside	2,310	England	,,
Hart Fell	2,638	Scotland	,,
Jura Island (N. Pass of)	2,566	,,	,,
Kippure Mountain	2,465	Ireland	,,
Knockmealdown	2,601	,,	,,
Mount Battock	2,554	Scotland	,,
,, Leinster	2,602	Ireland	,,
Pendle Hill	1,816	England	,,
Plinlimmon	2,481	Wales	,,
Sawel	2,228	Ireland	,,
Sayrs Law	1,753	Scotland	,,
Sca Fell	3,229	England	,,
Slieve Snaght	2,011	Ireland	,,
Storr Mountain (Skye)	2,341	Scotland	,,
Water Corag	2,187	England	,,
Wisp Hill	1,950	Hebrides	,,
Malvern Hills	1,396	England	,,
Mendip Hills	979	,,	,,
Iceland and Faroe:—			
Snæfell Jokull	5,115	Iceland	A. B. L.
Hekla	5,210	,,	,,
Skalingefjeld, Isle Stromoe	2,172	Faroe	Stein.

ASIA.

Himalaya Chain:—			
Mount Everest, or Gaurisanker	29,002	Nepaul	Col. Waugh.[1]
Dipsang Peak, in Karakorum range	28,278	,,	,,
Kunchin-junga, W. part	28,178	Sikkim	,,

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[1] The heights in the Sikkim Himalaya are deduced from the observations of Colonel Waugh, Director of the Trigonometrical Survey of India. See 'Journal of As. Soc. of Bengal,' Nov. 1848; and 'Proceedings of Royal Geog. Soc.,' 1857.

Names of Places, Mountains, &c.	Heights in English Feet.	Countries in which situated.	Au
Kunchin-junga, E. Peak	27,826	Sikkim	Col.
Sishur	27,799	,,	
Dwalaghiri	26,862	Nepaul	
Diamer	26,629	,,	
Juwahir	25,670	Kumaōon	Herl
Junnoo	25,312	Sikkim	Wau
Jumnautri	25,500	Nepaul	Web
Dhaibun	24,740	,,	
Kabroo	24,005	Sikkim	Wau
Chumalari	23,929	Tibet	
Powhunry, or Donkiah Lah	23,175	Sikkim	
Kanchan-ghow	22,000	,,	Dr.
Momonangli, or Gurla	23,500	Tibet	Stra
Api Peak	22,799	Nepaul	Web
Peak No. 12	23,263	Between the Kali and E. branch of the Ganges	
,, 13	22,313		
,, 23	22,727		
,, 25	22,277		
St. George's Peak	22,500	Between the Ganges and Sutlej	
St. Patrick's Peak	22,638		
Gangoutri Pyramid	21,219		
Jownlee Peak (highest)	21,940	Kumaōon	
Kailas Peak	21,000	Tibet	Stra
Kohibaba	17,905	Hindoo Cush	Burn
Peak N. of Cabul	20,232	,,	
Dodabetta	8,640	India, Neilgherries	
Mahabuleshwar	4,396	W. Ghauts	Schl
Utakamund	7,278	Neilgherries	
Passes of the Himalaya :—			
Ibi Gamin, between Sikkim and Kishtour, .. Lat. 30° 55′ N.	20,459	..	Schl.
Gunshankur Pass, one of the highest points between the valleys of the Indus and the Sutlej	19,980	..	
Lum-kang, over the Karakorum, from the Changchenmo Valley ..	19,501	..	G. T
Mustagh	18,400	..	Godw
Karakorum	18,317	..	G. T
Yangi-la (over the Kuen-lun to Ilchi)	19,092	..	John
Chang-lang, over the Karakorum range	18,839	..	Hay
Masimik, north of Pangong Lake ..	18,457	..	
Chang-la, from Leh to Tauksi ..	18,368	..	G. T

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[1] For Lieut. Strachey's observations during his very interesting Journey to Lakes of Manasarowar, &c., *see* 'Journal of As. Soc. of Bengal,' Aug. 1848.

[2] R. Schlagintweit, 'Hypsometry of India, the Himalaya, and W. Tibet,' 4to.,

[3] Great Trigonometrical Survey of India.

Names of Places, Mountains, &c.	Heights in English Feet.	Countries in which situated.	Authorities.
Sugit, between Ladak and Yarkand	18,237	..	Hayward.
Sanju, over a spur of the Western Kuen-lun to Yarkand	16,612	..	Hayward.
Langpya Dhura, or Doora Ghaut ..	17,750	Himalaya	Strachey.
Elchi, in Kuen-lun Chain	17,379	,,	Schl.
Lipu Lek Pass	16,884	,,	Manson.
Niti Ghaut Pass	16,814	,,	Gerard.
Paralaha Pass	16,500	,,	Webb.
Shatoof Pass	15,500	,,	,,
Lachoong Pass	18,000	Sikkim	Dr. Hooker.[1]
Height of snow-line on Himalaya:—			
North slope	17,400	..	Schl.
South ,, ...	16,200	..	,,
On Karakorum range:—			
North slope	18,600	..	,,
South ,, ...	19,400	..	,,
Highest inhabited points:—			
Summer pastures at Larsa ..	16,249	..	,,
,, ,, Zuchen ..	16,222	..	,,
Permanently inhabited villages:—			
Hanlé	15,117	W. Tibet	,,
Chushul	14,406	,,	,,
Central Asia:—			
Elbruz	18,526	Caucasus	Freshfield.
Kazbek	16,546	,,	,,
Demavend	21,000	Persia	Kerr.
Ararat	17,212	,,	Parrot.
Kina Balu	13,698	Borneo	St. John.
Adam's Peak	7,420	Ceylon	Tennant.
Argæus	13,197	Asia Minor	A. C.[2]
Beloukha	11,062	Altai	,,
Mount Lebanon, Dahr el Khotib (highest point)	10,050	Palestine	French Survey.[3]
Djebil Sannin	8,577	,,	,,
Pass of Hammana, highest point of road between Beyrout and Damascus	5,060	,,	,,
Mount Hermon	9,376	,,	Maj. Scott.
,, Horeb	8,593	,,	Rüppell.
,, Sinai	7,413	,,	Holland.
,, Catherine	8,665	,,	,,
,, Carmel	1,800	,,	Symonds.

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[1] 'Journal of Geographical Society of London,' vol. xx. p. 49.

[2] The Heights followed by the letters A. C. have been taken from Humboldt's 'Asie centrale.'

[3] Carte du Liban du Dépôt de la Guerre, Paris, 1862.

Names of Places, Mountains, &c.	Heights in English Feet.	Countries in which situated.	Auth
Antilebanon	7,000	Palestine	Porter.
Jebel Serbal	6,607	,,	Hollan
Mount of Olives	2,724	,,	Schub
Kamen Peak	5,397	Ural	A. C.

AFRICA, AND ISLANDS IN THE ATLANTIC.

Mount Atlas (Miltsin)	11,400	Marocco	Washi
,, Abba Jarrat, Lat. 13° 10′ N.	15,088	Abyssinia	Rüppel
,, Buahat .. ,, 13 12 N.	14,362	,,	,,
Kilimandjaro .. .. ,, 4 0 S.	20,065	Equat. Afr.	V. der
Mount Woso .. .. ,, 6 30 N.	16,350	S. Ethiopia	D'Abb
,, Dajan .. .. ,, 10 15 N.	15,740	N. Ethiopia	,,
,, Sowayra	10,328	Abyssinia	Markh
Table Mountain	3,816	Cape of Good Hope	A. B.
Pico Ruivo	6,056	Madeira	Vidal.
Peak of Teneriffe, or de Teyde ..	12,205	Canaries	Piazzi
Altavista Observatory, Teneriffe ..	10,073	,,	,,
Guajara Observatory, Teneriffe ..	8,903	,,	,,
Chahorra, Teneriffe	9,885	,,	Von B
Pico de Cruz, Palma	7,730	,,	Vidal.[2]
Los Pexos, Great Canary	6,400	,,	,,
Alto Garaona, Gomera	4,400	,,	,,
Peak of Fogo	9,154	Cape Verde Is.	Deville
Pico, Island of San Antonio	8,815	,,	Capt.
Pico, Island of Pico	7,613	Azores	Vidal.
Pico de Vara, Island of St. Michael's	3,570	,,	,,
Caldeira de Sta. Barbara, Terceira	3,500	,,	,,

AMERICA.

North America:—

Mount St. Elias	17,850	N. America	Rogers.
,, Fairweather	14,788	,,	,,
Fremont's Peak, Rocky Mountains	13,570	,,	,,
Mount Hooker ,, ..	15,700	,,	,,
,, Whitney, Sierra Nevada ..	15,000	,,	Whitne
,, Washington, highest point of the Alleghanies	6,428	,,	Rogers.

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[1] From the table of a great number of Geographical Positions and Heights de by M. A. T. d'Abbadie, during his travels in Abyssinia.

[2] The heights given on Admiral Vidal's authority are taken from the Surveys of the Canaries, and Azores, executed under his direction, and published by the Ad those on Mr. Piazzi Smith's were obtained in 1856, during his astronomical expe Teneriffe, where he remained for several weeks engaged in making physical obser the elevated stations of Guajara and Altavista.

[3] From Rogers' and Keith Johnston's 'Atlas of the United States,' 1857.

Names of Places, Mountains, &c.	Heights in English Feet.	Countries in which situated.	Authorities.
Popocatepetl	17,717	Mexico	Humboldt.
Orizaba	17,374	,,	,,
Iztacihuatl	15,705	,,	,,
Nevado of Toluca	15,542	,,	A. B. L.
Sierra Nevada	15,170	,,	Humboldt.
Perote Mountain	13,413	,,	,,
Jorullo	4,265	,,	,,
Volcan de Fuego	13,930	Guatemala	Lepelin.
,, Atillan	11,510	,,	,,
,, Pacaya	7,100	,,	,,
Irasu, or Volcano of Cartago	11,480	Costa Rica	Phys. Atlas.
Volcan d'Orosi	8,650	,,	Squiers.
,, de los Votos	9,840	,,	,,
,, San Salvador	8,000	,,	,,
Mountain Passes in N. America:—			
Pass over the Sierra Nevada, California .. .. Lat. 37° 28′ N.	12,400	Sierra Nevada	Whitney.
Lewis and Clarke's Pass	6,323	Rocky Mts.	Squiers.
South Pass	7,490	,,	,,
Cañon Blanco Pass, Lat. 35° 20′ N.	6,917	,,	Bell.
West Indies:—			
Blue Mountains	7,277	Jamaica	Trautwine.
La Souffrière	5,108	Guadaloupe	,,
Montagne Pelée	4,432	Martinique	Monnier.
Mount Garon	4,370	St. Vincent's	Chisholm.
South America:—			
La Silla de Caraccas	8,600	Venezuela	Humboldt.
Cerra de Duida	8,280	,,	,,
Roraima .. .. Lat. 5° 30′ N.	7,450	Guiana	Schomburgk.
Plain of Bogota	8,730	,,	Humboldt.
Volcano of Tolima	18,020	Andes of N. Granada	,,
,, Purace	17,034	,,	,,
,, Cumbal	15,620	,,	Boussingault.
Cayambe	19,535	Andes of the Equator	Humboldt.
Antisana	19,137	,,	
Cotopaxi	18,775	,,	,,
Pichincha	15,924	,,	,,
Chimborazo	21,424	,,	,,
Illinissa	17,380	,,	Bougeur.
Tunguragua	16,424	,,	Humboldt.
Sangaï	16,138	,,	La Condamine.
Vilcañota Peak	17.525	Peru	Pentland.[1]

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[1] Most of the heights given in this table on Mr. Pentland's authority have been taken

Names of Places, Mountains, &c.	Heights in English Feet.	Countries in which situated.	Auth
Apu-Cunuranu	17,590	Peru	Pentlan
Guaracoota Peak, Snow-line	16,217	,,	,,
Cololo .. .. Lat. 14° 58′ S.	17,930	Bolivia	,,
Volcano of Arequipa	20,320	Peru	,,
Chipicani, or Nevado of Tacora ..	19,745	,,	,,
Parinacota	22,030	,,	,,
Sahama	22,350	,,	,,
Gualateiri .. .. Lat. 18° 23′ S.	21,960	,,	,,
Ancohuma, S. Peak	24,286	Bolivian Andes	,,
,, N. Peak	24,043	,,	,,
Chachacomani, N. Peak	20,355	,,	,,
Angel Peak .. .. Lat. 16° 10′ S.	20,115	,,	,,
Supaïwasi, or Huayna Potosi ..	20,260	,,	,,
La Mesada, S. Peak	19,356	,,	,,
Illimani, S. Peak	24,200	,,	,,
Mountain of Potosi	16,152	,,	,,
Peak of Doña Ana	16,070	,,	Domeyk
Aconcagua Mountain	23,910[2]	Chile	Beechey Fitzr
Concal Peak .. .. Lat. 33° 6′ S.	20,386	,,	Gilliss.
Tupungato .. .. ,, 33 23 S.	22,016	,,	,,
Maypu Volcano	17,644	,,	,,
Volcano of Osorno, or Llanquihue	7,550	,,	Fitzroy.
Minchinmadava Volcano	8,000	,,	,,
Mount Stokes	6,400	Patagonia	,,
Mount Sarmiento	6,900	Tierra del Fuego	,,
Mount Darwin	6,800	,,	,,
Passes of the Andes:—			
Pass of Rumihuasi	16,215	Peru	Gay.
,, los Altos de Toledo	15,790	,,	Pentlan
,, Cordillera of Tingo	15,754	,,	Gay.
,, Paquani	15,340	Bolivia	Pentlan

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from his map of 'The Laguna of Titicaca, and of the Valleys of Yucay, Collao, an guadero,' published in 1848.

[1] The heights given on Mr. Domeyko's anthority are taken from his very int papers on the Geology and Mines of Chile, inserted in the 'Annales des Mines,' 1846,

[2] The height here assigned to the Peak of Aconcagua differs 700 feet from th by Admiral Fitzroy. A re-calculation, however, of his elements has led us to greater elevation for the giant of the Chilian Andes than given by that officer.

Fitzroy's observations place the summit of the Peak of Aconcagua, which on his incorrectly designated as a volcano, in lat. 32° 38′ 30″, long. 70° 0′ 30″ W., or 23′ and 100′ 45′ E. of Valparaiso, or its nearest distance about 88$\frac{9}{10}$ geographical miles. a station near Fitzroy's, at Valparaiso, the late Admiral Beechey found the angle o tion of Aconcagua, by several very careful observations, to be 1° 55′ 45″, the distar this station to the Peak being 88·74 geographical miles. From a review of the the compiler of this table has deduced for the height of Aconcagua 23,910 feet a sea. The American Astronomical Expedition to Chile, under Lieut. Gilliss, redu height to 22,300 feet.

Names of Places, Mountains, &c.	Heights in English Feet.	Countries in which situated.	Authorities.
Pass of Chullunquiani	15,160	Bolivia	Pentland.
,, Vilcañota, or la Raya ..	14,520	Peru	,,
,, el Paramo d'Assüay	15,528	Equator	Humboldt.
,, Quindiu	11,502	N. Grenada	,,
,, el Almorsadero	12,850	,,	,,
,, Come Cabello, Lat. 27° 30′ S.	14,520	Chile	Domeyko.
,, Doña Ana .. ,, 29 52 S.	14,849	,,	,,
,, el Portezuelo de la Laguna Lat. 30° 15′ S.	15,575	,,	,,
,, la Cumbre	12,572	,,	Lieut. Rae.
,, el Portillo, W. Pass	14,315	,,	,,
Mountains of Brazil:—			
Itambe	5,960	..	Eschwege.
Villarica chain, Serra da Piedade ..	5,880	..	,,
Itacolumi	5,750	..	,,

ISLANDS IN THE PACIFIC, POLYNESIA, AUSTRALASIA, &c.

Isle of Bourbon, highest point ..	8,340	..	Phys. Atlas.
Mount Ambotismene	11,506	Madagascar	A. B. L.
Adam's Peak	6,152	Ceylon	
Mount Slamat or Tajal	11,930	Java	Junghuhn.
,, Gounnong Pasama, or Ophir	13,840	Sumatra	Raffles.
,, Fusiama	14,177	Japan	Alcock.
Volcano of Matua	4,500	Kurile Is.	Phys. Atlas.
Peak of Unimak	8,593	Aleutian Is.	,,
Mowna Kea	13,953	Sandwich Is.	Wilkes.
,, Roa	13,760	,,	,,
Tobreonou	12,250	Tahiti	Phys. Atlas.
Mount Wellington, or Kosciusko ..	6,500	Australia	Strzelecki.
,, Lindsay .. Lat. 28° 20′ S.	5,700	,,	Mitchell.
Ben Lomond	5,010	Tasmania	Trig. Surv.
Cradle Mountain	5,069	..	,,
Mount Cook	13,200	New Zealand	Haast.
,, Tyndall	11,000	,,	,,
,, Egmont	8,840	,,	Dieffenbach.
,, Erebus	12,367	Antarctic Lands	Sir J. Ross.
,, Terror	13,884		

LAKES AND INLAND SEAS.

Sirikol, source of the Oxus	15,630	Pamir	Wood.
Manasarowar and Rakas Thal ..	15,250	Tibet	Strachey.
Titicaca	12,847	Peru-Bolivia	Pentland.
Victoria Nyanza	3,740	Central Africa	Speke.

Names of Places, Mountains, &c.	Heights in English Feet.	Countries in which situated.	A
Albert Nyanza	2,720	Central Africa	Bak
,, ,, ...	2,550	,,	(As by
Lake Tanganyika	1,844	,,	Burt Sp
,, Nyassa	1,522	,,	Kirk
,, Shirwa	2,000	,,	,,
,, Liemba	2,800	,,	Livi
,, Ngami	3,713	S. Africa	And
Baikal	1,535	Asia	A. C
Lake Chad	840	Cent. Africa	Dr.
,, of Van	566	Turkey in Asia	A. C
Aral	36	Asia	Schl
Caspian Sea, *below* the level of the Ocean	82	,,	Russ ve
Lake Pukaki	1,746	New Zealand	Haas
Dead Sea, *below* the Ocean	1,292	Syria	Jam
Lake of Assal, *below* the Ocean ..	570	Somali Country, Africa	
Great Salt Lake	4,290	N. America	Bell.
Utah Lake	4,790	,,	,,
Lake Superior, *above* the Sea ..	627	,,	Roge
,, Erie	564	,,	,,
,, Ontario	230	,,	,,
,, of Lucerne	1,407	Switzerland	Esch
,, of Geneva	1,230	,,	,,
,, of Celano (L. Fucinus).. ..	2,230	Italy	Aust
,, of Bolsena	967	,,	,,
,, of Thrasymene	812	,,	,,
,, Lugano	937	,,	,,
,, Como	692	,,	,,
,, Maggiore	650	,,	,,
,, of Garda	227	,,	,,

HEIGHTS OF SOME REMARKABLE INHABITE PLACES.

Thok Jalung Gold Mine	16,330	Tibet	Mon
Rumihuasi, Post Station	15,542	Andes of Peru	Gay.
Gartok, in the Upper Valley of the Indus	14,240		Mont
Jiachan, village	15,870	Upper Indus	,
Pati, Post Station .. Lat. 16° 05′ S.	14,400	Peru	Pent
Apo ,, ,, .. ,, 6 13 S.	14,376	,,	,
Ancochallani, farm .. ,, 17 35 S.	14,683	,,	,

Names of Places, Mountains, &c.	Heights in English Feet.	Countries in which situated.	Authorities.
Tacora, village .. Lat. 17° 47′ S.	13,690	Peru	Pentland.
Calamarca .. ,, 16 54 S.	13,650	Bolivia	,,
Antisana, farm	13,454	Equator	Humboldt.
Potosi, city	13,330	Bolivia	Pentland.
Puno, city	12,870	Peru	,,
Oruro	12,454	Bolivia	,,
La Paz, city	12.226	,,	,,
Cusco, city	11,384	Peru	,,
Tarma	10,027	,,	Gay.
Quito, capital of Equator	9,543	..	Humboldt.
Chuquisaca, capital of Bolivia	9,343	Bolivia	Pentland.
Bogota, capital of New Grenada	8,730	N. Grenada	Humboldt.
Mexico, city	7,570	Mexico	,,
Arequipa, city	7,852	Peru	Pentland.
San Salvador, city	2,115	Cent. Amer.	Squiers.
Highest village on S. side of the Himalaya	13,000	Kumäon	Strachey.
Tadum Monastery	14,200	Tibet	Montgomerie.
Janglache, town	13,600	Upper Brahmapootra	,,
Lhasa	11,700	Tibet	,,
Leh, or Ladak	11,600	,,	Strachey.
Level of the Indus at Leh	10,720	Kumäon	Schl.
Niti, village	11,473	,,	Webb.
Utakamund	7,490	Neilgherries	Waugh.
Simlah	7,156	Himalaya	
Darjeeling, town	7,165	Sikkim Himalaya	Waugh.
Sirinagur, capital of Cashmere Lat. 34° 4′ N.	5,144	Cashmere	Schl.
Khatmandu .. ,, 27 42 N.	4,350	Nepaul	,,
Cabul	6,382	Afghanistan	Burnes.
Arquaze, highest village in Ethiopia	12,235	Abyssinia	D'Abbadie.
Saka, capital of Enarea Lat. 8° 11′ N.	6,050	Ethiopia	,,
Kandahar	5,563	,,	Humboldt.
Teheran	4,137	Persia	A. C.
Hebron	3,029	Palestine	Russegger.
Hospital Great St. Bernard	8,110	Italy	A. B. L.
,, St. Gothard Alps, P.	6,808	Switzerland	,,
St. Veran, village .. ,, C.	6,693	Italy	,,
Breuil, village .. ,, P.	6,584	,,	P. S.
Denver, Rocky Mountains	5,180	N. America	Bell.
Jerusalem	2,610	Palestine	Lynch.
Bethlehem	2,704	,,	Russegger.
Damascus	2,200	Syria	Porter.
Madrid	1,994	Spain	A. B. L.
Santiago, capital of Chile	1,750	Chile	Pentland.
Munich	1,764	Bavaria	A. B. L.
Geneva	1,450	Switzerland	,,

Names of Places, Mountains, &c.	Heights in English Feet.	Countries in which situated.	Authoriti
Turin	755	Italy	A. B .L.
Lima	520	Peru	Pentland.
Vienna	436	Austria	A. B. L.
Milan	420	Italy	,,
Paris, Observatory	213	France	,,
Rome, Capitol	151	Italy	,,
Berlin	131	Prussia	,,

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